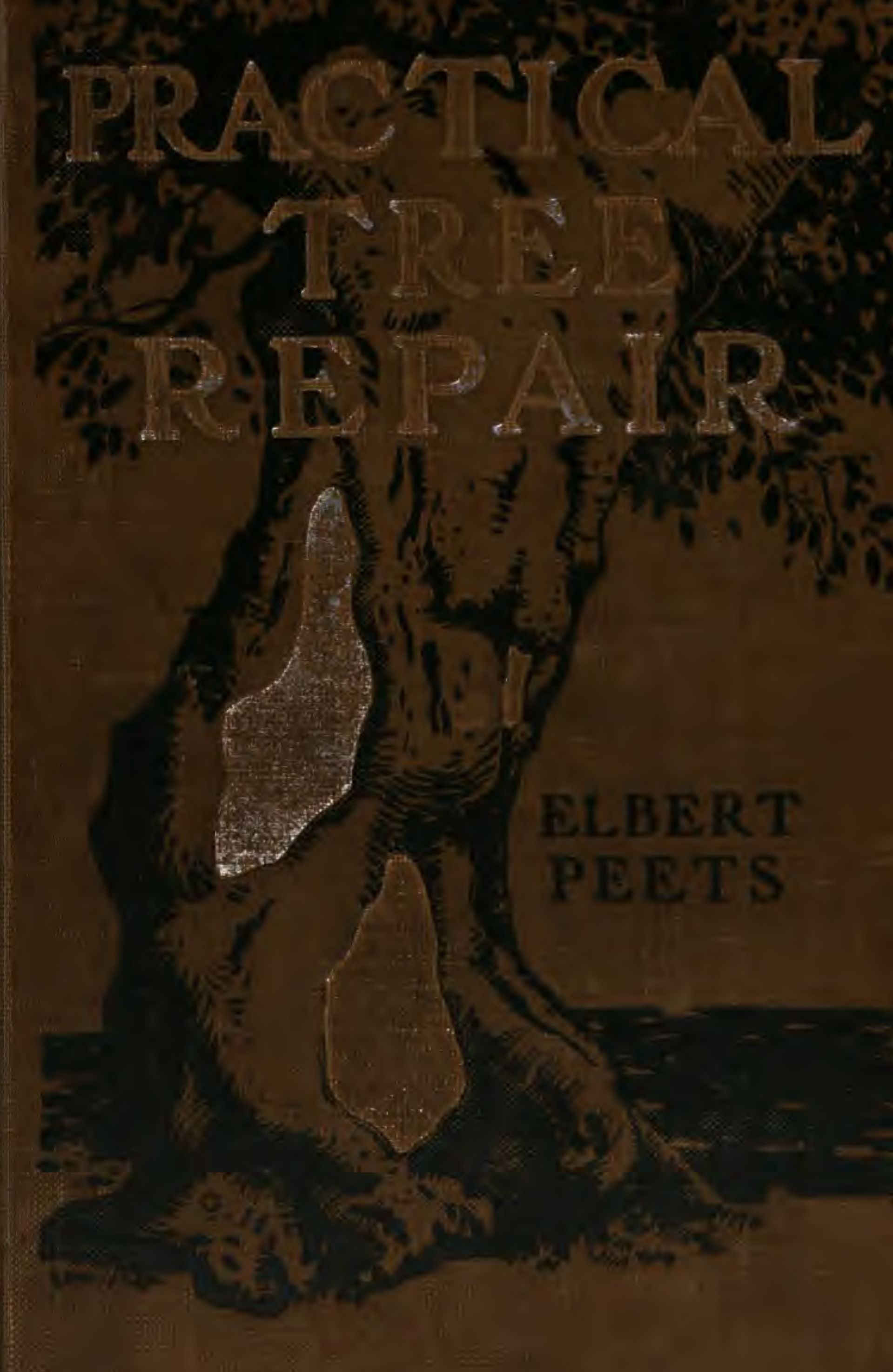
PRACTICAL
TREE
REPAIR
ELBERT
PEETS

PRACTICAL TREE REPAIR

Excavating a large cavity

PRACTICAL TREE REPAIR

THE PHYSICAL REPAIR OF TREES—BRACING AND THE TREATMENT OF WOUNDS AND CAVITIES

BY

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TO

MY FELLOW STUDENTS

IN THE SCHOOL OF LANDSCAPE ARCHITECTURE

AT HARVARD UNIVERSITY

INTRODUCTION

BECAUSE this book is a pioneer in its field, and because many popular misconceptions exist as to the nature of that field, and its relation to others, it may be well to state at the very beginning what the subject-matter is, of which the book treats. This is not a book on forestry, because forestry deals only with large tracts of woodland, the reproduction of forests, and the harvesting and marketing of timber. Men who concern themselves with the welfare of individual trees in towns and cities ought not to call themselves foresters — they are, or ought to be, arboriculturists. This book deals with one division of the science of arboriculture. It has nothing, or but little, to say concerning the planting, fertilization, pruning, or spraying of trees, all of which are important parts of the arboriculturist's work. It is devoted entirely to the prevention and repair of physical injuries to the framework of the tree, such injuries as are caused by wind and ice-storm, the ignorance or carelessness of men, the attacks of boring insects, and of that silent destroying host, the rot-producing fungi.

In a general way the field that it covers is the work often spoken of as "tree-surgery" or "tree-doctoring." Both of these terms have been rejected by most reputable arboriculturists for the reason that they produce in people's minds an anthropomorphic idea of a tree which is fatal to a correct understanding of a tree's nature and a tree's needs. A tree is a living thing, but it is not a human being and it is not an animal. The reasons for operating and the methods of operating upon trees and upon men are as entirely different as plants and animals are different. To say the contrary betrays ignorance of both kingdoms. There is no good reason why we should take over a word which already has acquired a definite meaning and apply it to quite a different group of facts and processes. To do so is bound to produce confusion of thought.

Although our knowledge of tree repair is now fairly considerable, it is by no means complete. There are a great many questions, both of principle and practise, about which keen differences of opinion exist among experienced men. Old methods have given way to new ones, and the process promises to continue. The new methods spread but slowly, and judgments as to their value differ. Inevitably, then, some readers of this book will find in it recommendations with which they cannot agree. Others will detect omissions. The writer will be extremely glad to exchange letters with any readers who will be so good as to give him the benefit of their ideas and their experience in the field of tree repair.

Some readers, to whom this book is an introduction to the work it describes, may at times feel that its directions are too general, and its statements too often qualified. A brief practical experience will show them the necessity for a certain degree of generality. No two trees are alike. In order that directions may not be misleading, they must often leave much to the judgment of the operator.

To make the book of positive practical value the author has overcome the extreme delicacy of so many writers in glossing over the names of manfacturers and their products. It is his honest conviction that in giving the results of his experience that his statements should be put in the most straightforward manner possible, without the concealment of a single detail that may be valuable or helpful to his readers. He has no logs to roll but merely the desire to educate.

During the preparation of the book the writer has received valuable help from many people. Mr. M. H. Horvath of Cleveland, landscape architect and consulting forester, and Mr. John Boddy, city forester of Cleveland, have answered many enquiries, and Mr. Boddy has furnished the originals of several photographic illustrations.

Dr. G. E. Stone has also furnished photographs, and has been so good as to spend much time explaining his interesting experiments and the work of his students at the Massachusetts Agricultural College. Mr. A. T. Hastings, Jr., City Forester of Jersey City, has very kindly supplied photographs. To these, and many others, the writer gratefully acknowledges his indebtedness.

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PRACTICAL TREE REPAIR

CHAPTER I

A PROGRAM FOR SAVING THE TREES

THE welfare of trees is now a subject of universal interest. Our cities are growing so big that it is not so easy as it once was to get out into the woods, and every bit of green is a relief from the glare of the city pavements. Around the city, too, suburbs are reaching out into the country, greatly increasing the value of the land, and in even greater proportion, the value of the trees standing on the land. The spreading meadow oak which ten years ago shaded the farmer's cows and escaped his ax only because its hollow bole gave little promise of fuel, has now become the priceless glory of some surburban garden. The old " maple bush " is now a well-kept park.

But the trees have not been treated with the consideration justified by their increased value. Their fellows have been cut away, exposing them suddenly to wind and sun. Their roots have been chopped off in digging roadways and cellars; the soil-water level to which they have become accustomed has been lowered by deep drainage pipes. Barren soil has been piled over their roots, robbing them of the air which is just as essential to them as water. Graders, teamsters, builders, and telephone men have treated the trees as their convenience suggested, tearing out their roots, bruising their bark, tying guy-wires to them and lopping off their branches, as if they were the dead and worthless things which, by the time the new suburban home is turned over to the owner, they too often are. Is it any wonder, then, that in most of our suburbs half the large trees are decayed and dying?

Out in the open country the conditions in the tree world are often much the same, though for different reasons. A good many groves, for instance, are now in existence solely by virtue of the fact that the trees in them are all decayed. I know of several beech woods in which every tree is hollow, for the simple reason that ten or fifteen years ago all the sound trees were felled for timber. Over-pasturing wood-lots has also ruined many beautiful groves. The cattle prevent the natural forest reproduction and compact the soil so that it dries out quickly, and the old trees can no longer make a vigorous yearly growth, and can no longer resist the attacks of their mortal enemies, the bark and timber borers and the rot-producing fungi.

It is obvious, then, that we are facing peculiar conditions, and conditions which call for a consistent line of attack. We must adopt a practical program. Such a program calls for three lines of procedure:

First, to see to it that our young trees are so planted and protected and attended to, that they may grow up to be healthy and perfect specimens.

Second, in the case of old trees which are still sound, to see to it that they are properly nourished and cared for, and painstakingly protected from accident and decay.

Third, in the case of old trees which are diseased and weakened, to make every effort, justified by the probabilities of success and the value of the trees, to repair them and restore them to health and strength.

The first and second provisions of this program are much more important than the third. Yet the third seems to be occupying a more prominent position, at least in the public eye, than the other two together. The reason, of course, is that "tree surgery," with its spectacular operations, has caught the popular attention, while those processes which aim at warding off decay and preserving health, with their less immediate results, have not made so great a popular appeal.

The history of the treatment of wounds and cavities in trees is of slight importance, but is still of considerable interest. Although it in all probability dates almost as far back as does the cultivation of fruit trees, the writer has not happened to stumble on any but the most meager references dating from earlier than the end of the Eighteenth Century. What might be called the modern history of the art begins, very regrettably, with charges and denials of quackery. Mr. William Forsyth, for many years king's gardener at Kensington, whose name has been immortalized in the form Forsythia, about the year 1800 discovered that a mixture of such plebeian materials as cow-dung, lime, and wood-ashes was a sovereign cure for wounds, and he even claimed that by its use "holes in trees may be brought to such a degree of soundness that no one can know the new wood from the old." Skeptics appeared and many open letters were hurled back and forth. Contemporary continental books on fruit growing described more promising dressings, and the systems of wound treatment they laid down were surprisingly sound in principle. An Englishman, Wm. Pontey, in his "Forest Primer," 1805, equals most modern writers in his grasp of basic principles. He advocates making pruning cuts close to the trunk, as is now universally done, and insists that cuts must be allowed to dry before they

Decayed maple before and after excavation. The work was done under the direction of A. T. Hastings, City Forester of Jersey City (see plate facing page 16).

are painted. Holes he suggests draining and filling with dry sand. The mouth he would plug with wood. " The plug should be driven so as to be level with the inner bark; as, by that means, Nature's efforts would not be obstructed in growing over it." The " Forester's Guide," published in Edinburgh in 1824, contains a description of the care of wounds which proves that its author, Robert Monteath, knew nearly as much about that subject as we do to-day.

Skipping a few years, we find some interesting notes in Count Des Cars' " Pruning of Forest Trees," which was first printed in 1865 and was translated from the French by Prof. C. S. Sargent. Des Cars' main theses were the importance of cutting close in removing limbs, and the value of severe pruning in restoring old trees. But he has something to say about cavities. As he is dealing with trees as timber, it is only relatively small wounds which interest him. These, he says, should be thoroughly cleaned and painted with tar and the opening plugged with wood.

With this start, the development of modern methods was easy. During the early period, we must not forget, trees were repaired mainly for their timber value. Trees which were badly decayed did not have sufficient value to make it worth while bothering with them. The fact that timber trees were being operated on also had an important effect on the choice of materials for filling. Timber trees obviously must not be filled with anything which cannot be sawed or chopped through. Pontey doubtless meant his dry sand to be drained out before the log was sawed. It is doubtful if Des Cars' method can be improved on for timber trees. When, however, in this country, the increase of wealth in the latter part of the last century greatly increased the value of shade trees, these restrictions were removed. Large holes were filled oftener than small ones, and men naturally began to fill up holes in trees, just as they would fill up a hole in a wall, with the only strong material ready at hand which could be fitted to an irregular shape — that is, with bricks and mortar or with concrete. Thus logically grew up the modern system of filling with concrete, a material which is just now being displaced, in part at least, by asphalt.

The present condition of the "tree surgery" business is in many respects unfortunate. In the first place a large part of the men who practise it in a small way have not the least idea of the structure of trees, the nature of decay, or the correct principles of treatment. They claim that every filling will soon be grown over, and yet they build out their concrete fillings so far that no callus can form over them. They paint cavities with tar to keep out the spores of fungi (or "germs," as they call them) and then they drive nails into the wood, opening up a hundred little cracks, ideal resting places for spores. Sometimes they put elaborate filling into one side of a tree and completely neglect an incipient bark decay on the other side, though that decay may girdle the tree and kill it in a few years.

The large "tree surgery" and "forestry" companies have at least a more intelligent idea of what they are trying to do, and most of their men are experienced and skilled in their trade. They have a tendency, however, to concentrate their efforts upon the conspicuous cavities, neglecting the smaller but not less important injuries. They do their work at great distances from their headquarters, and their work does not often receive that skilled yearly care which is essential to its ultimate success. The most regrettable feature of all has been that the "tree surgeons," enthusiastic about their art, and familiar with scarcely any other phase of arboriculture, have advised the filling of almost every diseased tree about which they have been consulted, regardless of expense or of the tree's "expectancy of life."

Every effort has been made to surround the work with an air of mystery. It appears that some mysterious inner harmony between the doctor and his arboreal patient is a prerequisite to successful treatment. As a result of these conditions, laymen frequently form (as they are intended to) an exaggerated idea of the importance of tree surgery and the certainty of its results. With their vision thus distorted they frequently rely too completely upon the filling of cavities, when, perhaps, the same money might be better spent in enriching the soil and planting young trees.

The remedy for this entire state of affairs lies in a more widespread understanding of the aims, methods, and limitations of cavity work in trees. It lies in a saner estimate of the comparative values of the various branches of arboriculture. The remedy, in other words, is to carry out, effectively and consistently, all three provisions of the program which has been outlined, instead of giving our attention mainly to the least important of them. It means that the public, the officials of cities and towns, landscape architects, arboriculturists, and the tree-men and gardeners who actually handle the tools, must cooperate in carrying out the whole program. And more than anything else, we need a greater number of — and a greater appreciation of — well-trained, all-round arboriculturists, men who know trees, how to plant them and how to keep them in health and protect them from danger throughout their lives; men capable of giving owners of trees rational, unbiased advice, and of seeing that it is effectively executed. And we need skilled arboricultural workmen in every city and town.

The purpose of this book is to help all of these groups to do a kind of work which has to be done, and done well, in carrying out effectively each of the three provisions of our arboricultural program — the prevention and treatment of wounds and the physical repair of trees. It aims to lay before the tree owner, or the man who is responsible for the welfare of trees, the information he needs for undertaking this kind of work himself, and which he needs no less if he is to hire, intelligently, men to do the work for him. It is also intended to serve as a handbook for those who now practice, or may take up, the work of tree repair as a profession.

Chapter II

THE TREE'S STRUCTURE AND MANNER OF GROWTH

THERE is no necessity, in a book of this character, for going deeply into the interesting sciences of tree morphology and tree physiology. It is, however, quite essential that a simple account be given of the nature of arboreal life, and especially of those points in the tree's structure and manner of growth which make possible the physical repair of trees. An understanding of these basic principles is just as necessary to the man who would repair trees as a thorough knowledge of human anatomy and physiology is necessary to a physician or a surgeon. All three do their work by virtue of certain natural laws, which they must know well before they can effectively use them. And, aside from the mere utility of such information, the effort required for its acquirement is repaid a hundredfold by the interest it adds to every day's work in the trees and every walk in the woods.

The word tree, like many other common words, is not easy to define, but it will probably be safe to say that we usually understand by it a sizeable, self-supporting, woody plant with a single stem. Trees have a definite place in the vegetable world. They are plants which, in order to get light and moisture, lift their leaves higher in the air than the average, and push their roots deeper and wider in the soil. This is the ruling principle which has controlled the development of trees, and which has made them as successful as they have been in their struggle against their plant competitors. It has controlled almost completely their shape, structure, and manner of growth. So great is the height to which they must attain in order to overtop their herbaceous and shrubby rivals for light, that so much growth cannot be produced in a single season. The growth must be cumulative, lasting over from one season to another, and must be strong and elastic, so that it will support large leaf-surfaces high up in the air. The tree must spread out, too, as well as go up, for in that way it can get the greatest amount of light and can save for its own use the nutriment and moisture in the soil below it, by preventing evaporation and the growth of other plants. As it grows higher and wider every year, gaining a greater and greater advantage over its competitors, its framework must become proportionately stronger and stronger. In other words, its trunk and branches must grow. The roots must spread farther and grip the soil more firmly every year, so they, too, must grow.

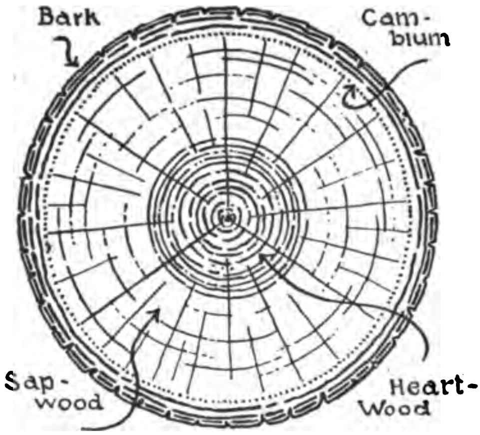
Now growth can take place in two ways. A thing can expand or grow from within simultaneously in all its parts, as a dry sponge grows when it is dropped in water, or it can grow by addition to its outer surface — be built up. Some plants, such as corn and the palms, grow in the first way; the rest, including all the northern woody plants, grow in the second way. The second is obviously the better way for the development of a framework combining economy with strength and easy "grow-ability," because the light and strong tissues are so firmly woven and cemented together that expansion, or growth throughout the stem, is practically impossible. The trunks, branches, and roots of our trees, then, are growing each year by the addition of a layer, completely covering them, of new wood.

The frame of a tree not only supports the foliage but also acts as a circulation medium between the roots and the leaves. The roots absorb water and mineral salts from the soil, and this crude fluid passes up to the leaves, where a small part of the oxygen and hydrogen in the water are combined with carbon dioxide taken from the air, and where, by use of the energy of the sun's light, the green "chlorophyll bodies" in the leaves combine these simple elements into complex compounds known as carbohydrates (sugar and starch), which, dissolved in water, make the digested sap. It is this digested sap which alone can produce growth and can furnish the living cells with the nourishment they need while they are growing and multiplying. Even the roots depend for the material of their growth upon this digested sap from the leaves, the crude fluid they absorb from the soil being of no nutritive value.

There are thus two streams normally flowing through the trunk. One, flowing up, is of crude sap from the roots, and the other, flowing down, is of digested sap from the leaves. These streams flow through separate concentric regions in the tree's trunk. What has already been said about the wood of the trunk being added to from the outside ought to give us a hint that the region carrying the digested, growth-producing sap, is the outer — and such it is.

With these general principles in mind, let us glance at a cross-section of a young oak trunk. Three concentric rings are at once noticeable, the dark corky bark on the outside, the heartwood in the center, and the lighter sapwood between them. But more important to us than any of these is a fourth ring, a very inconspicuous, soft, moist layer between the bark and the sapwood. This is the cambium layer.

The cambium layer is the great fact to the man who is doing tree repairing. If an accident occurs, his first thought is of the cambium. If he is making an incision or filling a cavity, one eye must be constantly on the cambium. He must learn all its wills and won'ts, what it does and how it does it, what can be done to it and what can not.



Cross section of the trunk of a tree

For the cambium is the only growing part of the tree (besides the young leaves and the tips of twigs and roots) and if growth is to be made the cambium must make it. It is the vital, growing cambium which each year lays on a thin, strong layer of new wood over the whole surface of the frame of the tree, which builds out a tough shield of bark to protect itself and the wood beneath it. It is the cambium which heals wounds and covers over cavities.

More specifically, the cambium is a layer of cells lying between the wood and the bark of the tree, which, under proper conditions of temperature and nutriment, have the power of growth and division; that is, of producing new cells. Most of the new cells produced by this multiplication are deposited either on the wood which is inside the cambium, or on the inside surface of the bark, which is outside the cambium, and these cells quickly lose the characteristics of cambium cells and become specialized wood or bark cells. They of course no longer have the power of growth or division, and in that sense all the cells in the trunk except the cambium cells and the innermost bark cells, which in many ways work with the cambium, are dead.

Leaving the cambium for a time, let us glance at the other regions of the trunk. The sapwood has for its function the conveyance of water (with small amounts of minerals dissolved therein) from the roots to the leaves. The sapwood (of the roots as well as of the trunk and branches) also acts as a storehouse in which digested food is laid up over winter. The principal effect of the removal of sapwood from the tree is that the water supply of the leaves is cut off.

The heartwood has no physiological function, though it may help the sapwood a little at lifting water. The great importance of the heartwood lies in its resilient strength as a support to the crown of the tree. It is just as dead in the tree as it is when it is cut up into boards and built into a house. It can be removed from the tree by man or by fungous decay without the least injury to the tree, provided the strength it represents is not needed, or can be supplied in some other way.

The bark is made up of cells produced from the cambium or a sort of assistant cambium called the phellogen. In rough-barked trees the bark is added to from within in annual layers. The pressure generated by this constant addition from within, added to that caused by the annual increment of the wood itself, causes the outer layers of the bark to break in irregular fissures, and ultimately to slough off in plates and flakes. In the smooth-barked trees a different method is pursued. The beech, for instance, has but very little corky bark, most of the apparent bark being live "phloem" tissue, which meets expansion by itself growing and expanding, thus preventing the formation of furrows in its surface. The sole purpose of the bark is to protect the cambium and wood.

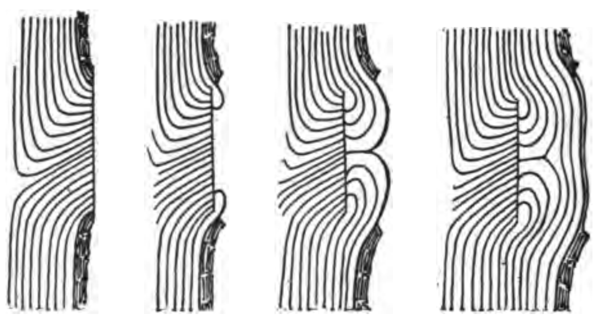
It is in the cambium, as we have seen above, that the digested sap from the leaves circulates about the tree and passes down into the roots. Cambium cannot live without some of this sap, and cannot produce thrifty growth without a plentiful supply

The same tree as that shown in plate facing page 4, reinforced with rods and wire and filled with concrete

of it. Insomuch as the main current of sap is from the leaves to the roots (and in spring from the roots to the young growing twigs, for the sap which supplies them with the materials of growth is mostly stored over winter in the roots), it is obvious that cambium that lies in this circuit will be best nourished and grow fastest, and that patches of cambium which for any reason lie aside from the main thoroughfares of sap circulation will receive least sap and will produce the least growth, and that patches which are completely isolated will of necessity die. These facts govern the making of incisions and the healing of wounds in trees.

A careful study of the healing of wounds is an excellent preparation for making incisions, which are only purposive wounds.

Suppose we cut a small limb from a tree, following the practice of good pruners by making the cut very close to the trunk. The result will be an oval or egg-shaped wound with the cambium of the trunk showing near its outer edge. The sap in the cambium tends to flow in the direction of established paths and in the direction of least pressure. The exposed cambium around the edge of the cut being such an area, it will receive a large flow of sap. The unconfined cells will multiply rapidly. As a result of this rapid growth a fold or lip will be thrown out from the region of the cut cambium layer all around the wound. It will press firmly against the cut surface, covering and protecting it. A cross-section of this callus will show that it is structurally like other parts of the trunk, a layer of bark enclosing a thin layer of cambium, beneath which is the sap-

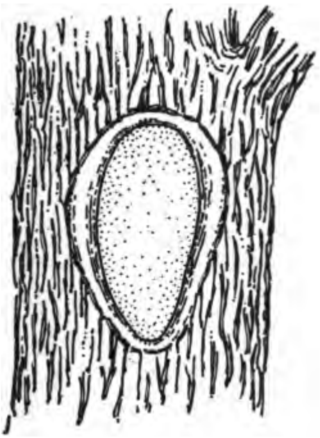


Vertical section through a pruning wound and the first, fourth, and seventh years subsequently, showing growth of callus

wood, though the wood of a callus is harder and more closely woven than ordinary wood. Every year a new layer of wood will be deposited on the callus by the callus cambium, and before many years the wound will be completely covered.

The callus does not, of course, actually coalesce with the cut surface, but merely rolls over it. As wood is added to the inner edge of the fold, the bark which is under the lip, so to speak, is pressed against the cut surface, and if the limb were sawed in two through the callus a thin layer of dead or dormant bark would be found beneath the callus, dividing it from the surface it has spread across.

During the healing process we will usually discover that the callus grows most rapidly at the



Normal callus growth around oval wound

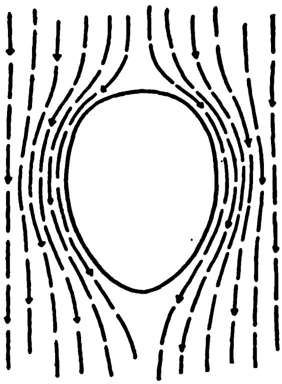
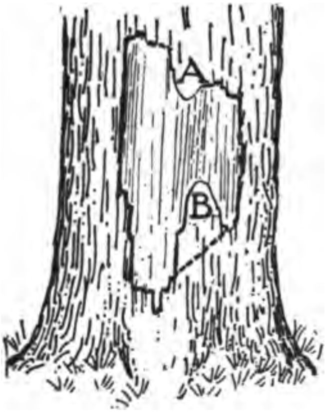


Diagram of the flow of sap about an oval wound

sides of the wound, more slowly at the top of it, and most slowly at the bottom. The reason for this is indicated by the accompanying figure, which is a diagrammatic representation of the flow of sap through the cambium around a wound in the trunk. The sap tends to flow in a fairly straight line. The greatest flow is past the sides of the wound. Less comes to the top of it, and the lower edge is in a sort of back-water, where it gets but little nourishment. In some cases, as often on the oak, these differences are not so distinct.

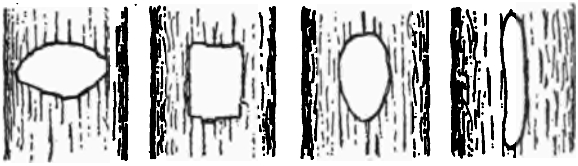
The effect of the tendency of the sap to flow in continuous vertical channels is well illustrated by the results of the way sap has of flowing by an irregular bark wound. Suppose that a patch of bark of the shape indicated in the diagram is torn from a trunk, and that the exposed cambium dies. What will happen is obvious enough. The tongue B (see drawing), being entirely isolated from the flow of sap (which, it must be remembered, is normally downward), will soon die back to the dotted line. The tongue A will probably die, but that is not so certain, for projections from the upper edge of a wound stand a better chance of getting nourishment. Calluses will of course be formed at the sides of the wound.



An irregular bark wound

On the basis of these observations, we can formulate a general rule for the shape of incisions.

The ideal incision is egg-shaped or oval, with the longer axis lengthwise of the trunk or limb in which the incision is made. As it happens, this is the shape of the wound usually made in cutting off a limb close to the trunk. It is highly desirable that the incision be as narrow as possible, but its height, or dimension lengthwise of the trunk or limb, is not so important. The flow of sap is



Four incisions in trees, the one at the left being the most damaging and slowest to heal; the one at the right least damaging and quickest to heal

not much more seriously interfered with by a cut six inches wide and three feet high, than by one of the same width only one foot high, and will heal as quickly. In some trees, especially apples and beeches, the bast fibers are often laid on in gentle spirals around the trunk, indicated outwardly by the fissures and ridges in the bark. In such cases the incisions should follow the direction of the fissures.

The proper location of incisions, when choice can be exercised, is as important as shaping them correctly. When there is a vigorous ridge in the trunk, standing out like a flexed muscle, connecting a large limb with a principal root, it is obviously undesirable to cut across it. Removing the cambium would rob the root of its due supply of digested sap, and removing the sapwood would cut off the water supply of the limb above it. In the same way, a wide incision should not be made just above a thrifty root, nor just below a large limb. In case a series of holes must be cut into a tree in order to remove decay, it is probably best to cut one directly above another, or, if the tree is twisted, in a spiral. By that arrangement there is a minimum of interference with the flow of sap. There is considerable likelihood, however, that the bark between the incisions will die, in which case it should be cleaned away, and the exposed wood should be painted.

CHAPTER III

WOUNDS AND THEIR TREATMENT

WOUNDS are perhaps the most frequent primary cause of the decay and death of trees. The vast majority of the destructive rot-producing fungi can make their entrance into the framework of the tree only through wounds. We shall discuss these decays at greater length in another chapter, but it is essential that, at the very outset of our study of practical tree repair, we clearly understand the danger which lies in wounds. By wounds I mean all exposed surfaces of wood, all interruptions in the normal bark covering. Wounds are not simply esthetically displeasing, marring, for instance, the fine texture of the bark, nor do they merely interfere more or less seriously with the physiological processes of the tree. Wounds are breaches in the tree's great wall of defense, its bark, laying the precious treasures of its wood open to the unresisted attack of its thousand omnipresent enemies. If you come upon the brown shelf-like fruiting bodies of certain rot fungi in the woods on a bright day in fall, you will see coming from their lower surfaces little clouds of brown dust. Each particle of this fine dust is a spore which has the power to grow and cause decay and to reproduce the mother plant. How certain it is, then, that every wound in a tree will sooner or later become infected by some tree disease, and that every wounded tree is a tree in danger.

There are two general purposes or principles which govern the treatment of wounds. We must handle wounds in such a way as, first, to prevent the entrance of decay and of insects, and, second, to facilitate their healing. The first purpose is of more immediate importance, on account of the slowness of the healing process, which often cannot take place at all if decay precedes it. The second is, however, of great ultimate importance, because healing entirely obviates the danger of infection and helps the tree physiologically and physically.

The materials used in disinfecting and treating wounds will be considered first, and then the different kinds of wounds trees receive most often, and the way each kind must be handled.

To keep insects and fungi from entering through them, wounds must be covered with some kind of protective dressing. Many different materials have been used for this purpose. Just at present the matter of wound dressings is coming to be a subject of careful investigation by arboriculturists. There is a strong tendency to question the value of materials which have long been accepted as effective. Take paint and tar, for instance. Men who have much to do with shade and orchard trees are constantly coming upon old wounds, apparently painted or tarred with care when they were made, which are now dotted with the exit holes of borers, and netted with season checks. The wood at the surface of the wound may seem substantially sound, but a blow with an ax discloses the decayed and crumbling wood within. In spite of these facts the general teaching has been that nothing more is needed, in treating a wound, than a dressing of paint or tar. The permanence of the dressing on the surface, even after the decay has slipped by it into the tree, has retarded the discovery of the actual ineffectiveness of paint and tar.

It may be answered to this that paint and tar are not at fault, but rather the way in which they are used. That is in large part true. A wound-dressing, even the best, is not a charm, and must be carefully applied and renewed if it is to be permanently effective. It is also true that there are many kinds of paint and of tar. It is no less the purpose of this discussion to point out the right use of the old materials than it is to describe the new ones. The man who can knock out the general idea that a wound is dressed mainly for the sake of appearances, as people are, will do more good than the inventor of an improved preparation.

Any discussion of dressings for wounds must be prefaced by a determination of the things the dressing is to be called on to do and of the influences which tend to prevent the proper discharge of its functions.

The dressing is put on the wound in order to prevent weather, insects, and fungi from getting at the exposed wood. The weather does but little harm *per se,* but it is the invariable advance agent of fungi. To be good, a dressing must cover the wound completely, bridging such small cracks as there may be in it, must take tenacious hold on the wood, weather well, and not crack or separate from the wood. It must, in addition, be fairly easy to apply, and must if possible be cheap.

That it is hard to find a satisfactory dressing is largely due to the kind of surface to which it is applied. Because the surface to which it is applied is usually moist it is hard to make the dressing adhere, and because the surface is sure to check it is hard to get a permanent covering. Painting a wound in a tree is absolutely unlike painting a piece of seasoned timber. It is sometimes suggested that the dressing ought to prevent evaporation and the checking of the wood, but in practice it has been found that no dressing will prevent the

Wounds at the base of a beech caused by lawnmowers

A tree that has made repeated efforts to cover successive wounds

checking of fresh-cut wood. The wisest thing to do is not to try to put on a permanent dressing until the first checking has taken place. A heavy dressing will then retard further checking and may not be fractured by such checking as does occur.

The various materials which have some value as applications to wounds can be divided into two groups: those which sterilize the wound and cause the death, through their fungicidal properties, of such spores as fall on the wound while the materials persist, and those materials which fill and cover the wood, permanently preventing the access of spores to it. Some of these last have incidental antiseptic qualities.

To the former class belong all sprays used against fungous diseases, such as solutions of copper sulphate and the lime-sulphur wash. Whenever trees are sprayed with a fungicide the nozzle should be held for an instant against each wound, and the trunk should be sprayed as carefully as the bearing wood. The copper solution is made by dissolving an ounce of copper sulphate in a gallon of water. Other antiseptics of value in dressing wounds are corrosive sublimate, dissolved in water at the rate of two ounces to fifteen gallons, and formalin, one ounce to two gallons.

The antiseptic materials used in wood preservation are also of value in treating wounds. Foremost among them are coal tar creosote and carbolineum, which is also a coal tar product, distilled off at a higher temperature. Creosote comes in several consistencies, the heaviest of them requiring heating. A so-called creosote is made from the tar which is a by-product of the manufacture of water-gas from petroleum, but it has no antiseptic value. In buying creosote demand a guarantee that it is distilled from coal tar. Two safe brands, besides carbolineum, are the "Letteney" wood preservative, sold by the Northeastern Company of Boston, and the "C. & A." creosote. Carbolineum has been the center of much controversy. Some observers claim it never hurts the bark or living tissue of the trunk, while others can prove that trees have been killed by it. Until it is determined under what conditions it is safe, the manufacturers warn against the application of carbolineum to the bark or to the sapwood close to the bark. To large surfaces it can of course be applied without danger, and for such purposes it has great value, as it penetrates very deep, especially if it is heated.

Creosote and carbolineum, both of which, by the way, are commonly carried by paint dealers and cost from sixty-five cents to a dollar or so a gallon, do not actually fill the wood in the sense that paints do, but they make the wood impervious to water and immune from the attacks of insects. The reason why they cannot be considered as complete dressings is that they do not to any extent prevent the checking of the wood, even when they are frequently renewed. They cannot in any way fill or bridge over cracks. Checking continues, though slowly, for an indefinite period. Ultimately, the cracks get so large, if they are not covered over, that water gets into them and, freezing, tends to break out bits of the wood, thus exposing the unimpregnated inner regions. For this reason chemical preservatives, as distinguished from dressings which produce a mechanical covering, have not proved successful permanent applications for wounds.

Of these materials which do actually fill and cover the wood, paint is probably the most used. Pure white lead and linseed paint makes a very good dressing for moderately small wounds, especially if the wood is dry when the paint is applied. Its effectiveness is much increased if a second application is made after the first checking has taken place. Paint seems especially suitable for ordinary orchard practice, where the wounds are not large or inaccessible and healing is fairly rapid. It would not do to ignore Prof. Bailey's judgment in such a matter. " My conclusion is," he says, " after having had the question in mind for a decade, that a heavy application of lead paint is the best all-round dressing for common pruning wounds." The tree repairer, however, has often to deal with quite different affairs from ordinary pruning wounds. Suppose a large wound is painted. In a year or two season checks form in the wood and the inelastic paint fractures. Boring insects find little crevices in which to deposit their eggs. The larvæ burrow back and forth in the wood, returning as adults to the wound to emerge. At the surface the paint may stop them temporarily, but the strong jaws of the insects soon break it down. Each hole thus left, with a moist mass of sawdust extending back into the wood, is an ideal germinating bed for fungus spores. In four or five years more the wood is quite rotten, large cracks appear in its surface, ants and other insects have free access. Soon the wound is beyond any cure but a more or less expensive cavity treatment. Repeated observation of this process has lead the writer to conclude that a single coat of paint is a positively dangerous dressing for large wounds, concealing, as it does, the disintegration which goes on underneath it almost as rapidly as if the wound had not been dressed at all.

A very permanent dressing is the plastic cement used by slaters. It is applied in a thick layer with a spatula. It does not become hard nor crack if it is properly made. It has no antiseptic quality and must be preceded by an application of carbolineum. It is probable that the use of slaters' cement will become more common as the method of making two applications, one for sterilization and one for protection, is more widely adopted. Dr. G. E. Stone tells me he has had good success with the brand manufactured by the W. F. Webster Cement Company of Cambridge, Mass. Slaters' cement has the advantage of being very inexpensive.

Grafting wax is too expensive and adheres too imperfectly to entitle it to a place as a regular dressing, but the liquid form has important special uses. It is the best thing to apply to fresh wounds, because it does not in the least injure the cambium. The wax can be made at home according to the recipes to be found in Bailey's "Horticulturalist's Rule-Book," or it can be bought, costing about forty cents a pound. To make liquid wax of the ordinary kind, heat it and mix about half its weight of alcohol with it. It may be well to give Bailey's recipe for "Lefort's liquid grafting wax." "Best white resin, one pound; beef tallow, one ounce; remove from the fire and add eight ounces of alcohol. Keep in closed bottles or cans."

Next to paint, tar has been the material most commonly used as a dressing for wounds. There are several different kinds of tar. To dispose first of the undesirable ones, the material known as "coal tar paint" is merely a solution of some kind of asphaltum in benzine and has no value as a wound dressing. It does not spread thickly, dries brittle, and is rapidly dissolved by water. Pine tar, or pitch, is rather expensive, not very convenient to handle, and in no way superior to coal tar. A special warning should be sounded against those forms of tar which are hard and brittle at ordinary temperatures and have to be melted to be applied. Such are sure to chip off and be unsatisfactory.

Coal tar is the material intended wherever the word tar is used in this book. It is one of the residuums from the distillation of bituminous coal in the process of making coal gas. Coal tar is sometimes called gas tar, but that expression applies also to a by-product of the manufacture of water-gas out of petroleum. That sort of tar has no preservative value and should not be used on trees. In buying tar for that purpose the only safe way is to get it from, or trace it from, a gas works producing gas from coal. In case of doubt have the dealer sign a guarantee that the tar is wholly the product of the destructive distillation of bituminous coal.

Tar makes a very good dressing if it is carefully applied and if not too much is asked of it. It is at its best when heavy applications are made in winter, when it usually needs to be heated, to dry and not too large surfaces. It is absorbed by a transverse cut and is then to a certain extent subject to the drawbacks attendant on the use of such materials as creosote. It does not adhere well to moist surfaces, blistering up easily. On large wounds it must be frequently renewed. For instance, the writer once had to treat a large bark wound in an ironwood tree. The exposed wood was dry and sound, though rather deeply cracked. He applied at intervals of a week or two, during the summer, four thorough coats of tar. The conditions were ideal for a perfect job. Four years later there were numerous holes through the tar where insects had escaped and there were even cracks through which the wood was visible. This does not prove that tar is not a valuable dressing. It only shows that in this case four years was too long to wait before renewing the protective covering. That is the great point about the use of tar. It must be renewed at frequent intervals. How long those intervals can be depends upon circumstances. If a thorough second coat is given rapidly-healing pruning wounds up to say six inches in diameter, a year after the first coat, they can usually be left to heal without further attention. Larger wounds should receive a second coat the year after the first one and every second year thereafter, until checking absolutely ceases and a heavy impervious layer of tar is formed over the whole surface.

For the little odds and ends — petty injuries and quickly-healing wounds — a thorough daub of tar is quite sufficient. But the strong color and staining quality of tar must not be permitted to lead to careless work with it. It must be flowed on with a full brush, and every particle of the surface must be covered.

Observation of the poor results obtained from the use of paint and tar, in the way they have been used, has naturally brought about a search for better materials. A number of "pruning paints" have been put on the market and many others are being tried on a small scale. The Ohio Experiment Station has undertaken a systematic study of the various dressings. These experiments are hardly likely to result in the discovery of a better material than good coal tar, properly applied and renewed. But, as a matter of fact, tar dressings are *not* properly renewed, and these efforts to discover a material which does not require frequent renewals are thoroughly justified. They have, indeed, already given us several dressings which are superior to tar in this important respect.

The new materials are mostly forms of asphalt. Asphalt is a fairly pure solid bitumen resulting from the natural or artificial distillation of petroleum which, like western petroleum, has an asphalt base, as contrasted with those forms, such as our eastern petroleum, which have a paraffine base.

Frost crack in black oak on the grounds of the Harvard Observatory

Natural asphalt comes largely from Trinidad and Venezuela. Artificial or residual asphalts are distilled by several firms, notably Byerly & Son, of Cleveland, who call their product "Byerlite." The Barber Asphalt Company markets natural asphalt in many forms. The most generally useful solid form is their bituminous cement No. 143. The writer prefers it to the artificial forms. Both cost thirty dollars a ton. The solid forms of asphalt can be used just as they come, being melted for use. There are serious difficulties, however, about applying hot preparations to tree wounds, particularly if the wounds are high up in a tree. Most forms which need melting, also, dry too brittle to be perfectly effective. To avoid these drawbacks, the asphalt is usually fluxed with some liquid in which it will dissolve, just enough of the solvent being used to bring the mixture to the proper consistency. Many substances are used for this purpose, including gasoline, petroleum oils of various consistencies, linseed oil, and other vegetable paint oils.

The mixture can be bought ready made or can be made by the user. The most available commercial products are various water-proofing compounds, used in laying water-tables in masonry work. The heaviest of these materials should be chosen, and those should be avoided which are fluxed with gasoline or benzine, for the resultant coating is brittle and soluble. There are a number of compounds of asphalt made especially as tree dressings. The one with which I have most acquaintance is "Hoyt's Tree Varnish," a solution of asphalt in a permanent compound paint oil. It is an extremely good preparation, being thick, tough, and elastic. It has the drawback, though, of costing about a dollar a gallon. The same dealer (C. H. Hoyt, of Cleveland) puts up a water-proofer which he will mix especially for tree work, such as painting cavities, and sell at about forty cents a gallon. A number of pruning paints are advertised in the gardening magazines.

These asphalt preparations are, in general, not difficult to make. Simply melt the asphalt, take the vessel containing it a short distance away from the fire, and stir in the proper amount of the fluxing oil. Highly inflammable gases are produced during the mixing, especially if a mineral oil is used, and that is the reason for getting away from the fire.

Practically any form of asphalt can be used in making these preparations. The writer has found the Barber cement he has mentioned in many ways the most satisfactory, though the artificial asphalts give very good results. Further experiments may fix on some one form of asphalt as the best.

As a solvent, there is little reason for choosing the expensive paint oils over the cheap mineral oils. Linseed oil does not result in so permanent a dressing as does mineral oil. At the suggestion of Mr. John Boddy, City Forester of Cleveland, the Standard Oil Company has put on the market a special asphalt solvent, under the name "Varnolene." It costs about eighteen cents a gallon at Cleveland.

It is not easy to give definite directions as to the proportions to be used of solvent to asphalt. That depends on the melting point of the asphalt, the nature of the solvent, and the season. It is always wise to mix up small trial batches and let them cool to air temperature, in order to determine the proportion which is right for the existing conditions. The mixture as applied should be rather like a soft jelly than a paint, being just as heavy as it can be brushed on. If "Varnolene" is used the right amount of oil for each pound of asphalt will usually fall between a pint and a pint and a half.

Effective as a thorough coat of asphalt paint is, cases frequently arise which call for something even more strong and enduring. The wound may be a very large one, for instance, and difficult of access, so that little dependence can be put upon future renewals of the dressing. If it is an old wound there are probably borers beneath the surface which may be able to break through even a heavy coat of asphalt. To meet such a situation we have always the possibility of covering the wound with zinc or copper. There is a method, though, which secures quite as effective a covering as does zinc, with less expense and less work. That method is the reinforcement of ordinary brushed dressings.

A dressing is reinforced by applying a fabric to the wound and saturating the fabric with the dressing. The materials available for this purpose are numerous, such as cotton batting, burlap, cheesecloth, and canvas. By all means the most satisfactory, though, is cotton padding, a material used in dressmaking. It is a thin bat of cotton, perhaps an eighth of an inch thick. All department stores sell it, the price being about five cents a square yard.

Three steps must be observed in applying the reinforced dressing. First give the wound a thorough coat of the dressing. It is well to let this dry a day or two. Then press the padding against the wound and saturate it thoroughly with the dressing. At this point the padding which extends beyond the edges of the wound can be trimmed off. It takes only a moment to trim the edges if a sharp instrument is used. The writer uses old safety razor blades. When this saturating coat has dried a few days the upper surface of the cotton padding will usually be somewhat exposed. A final surface dressing is necessary in order to protect the cotton from the weather. When the job is done the presence of the cotton is barely discoverable.

Not all dressings fit this process. Tar is apt to harden at the edges and separate from the wood. Paint would do fairly well, though it would be very expensive. The asphalt compounds work best. The first coat on the wound can be of tar, asphalt being used to saturate the fabric and for the final dressing.

The manufacturers of pruning paints often advertise that their preparations contain nothing which could be harmful to the tree. The writer does not consider that an important point. None of the materials commonly used is seriously injurious to the wood. Tar usually kills back the cambium an eighth or a quarter of an inch, but it is normally killed as far back as that by drying. Carbolineum often kills the cambium a little farther, but is innocuous if it is kept an inch or so from the edge of the wound. Don't choose an expensive material over a cheap one for the sole reason that its analysis indicates that it contains nothing which could possibly injure the cambium. The cheap one may in practice be just as good.

All this discussion of wound dressings has been necessary in order to make intelligible the brief and definite general rules for the treatment of wounds which can now be laid down.

Prune and make incisions, whenever possible, in late summer, fall, and early winter. Small wounds on fast-growing wood dress with paint or tar. If in a year they show season checks give them a second coat. Moist wounds saturate with a non-filling disinfectant. After checking has taken place and the wound is dry, put on a thorough coat of a heavy dressing. Large wounds, in which the exposed wood is seasoned, paint with creosote, then cover with a heavy protective dressing. If necessary, reinforce the dressing, or cover the wound with metal. It is extremely desirable that all wounds be inspected yearly, and that all injuries to the coverings be repaired promptly.

We come now to the different kinds of wounds trees receive, and the way to treat each of them.

Trees receive mechanical injuries in a thousand different ways. It would be impossible to enumerate them, nor is it necessary, for the measures of prevention and repair are much the same. It will be necessary only to pick out a number of typical injuries and describe the correct treatment of each.

The commonest kind of mechanical injury to the trunks of trees is the bark wound. Animals gnaw at the trees, vehicles run against them, gardeners bark them with lawnmowers, falling trees crush against them, farmers use them for fence-posts, carpenters drive nails into them, lovers cut hearts on them, and small boys try their little hatchets on their tender bark. For every kind of bark wound, no matter what its cause, the prescription is: "Clean up, disinfect, and seal." Yet even here circumstances alter cases, and the way the prescription is carried out must be adapted to the special cases. The differences depend mostly upon the length of time intervening between the making of the injury, and its treatment. It is extremely desirable that wounds be treated immediately after they occur. This is not, as might be inferred from the analogy of wounds in animals, to prevent infection, for infection takes place rather slowly, as a rule. Promptness is

Bark wound in which almost all of the cambium has been saved by prompt treatment desirable because by immediate attention the size of the wound can often be greatly diminished, and its healing can be correspondingly facilitated. This is by virtue of the fact that when bark is torn from a tree it is the mucilaginous cambium layer which lets go. Some of the cambium cells come off with the bark and some remain on the surface of the wood. If a sufficient number remain on the wood, and if they do not dry out, they have the power of growing and of developing new bark-producing cells, which rapidly replace the detached bark. It is obviously desirable to take advantage of this recuperative power of the cambium. When a tree is barked the wound must be protected from the sun and wind without a moment's delay, by replacing the torn bark or otherwise covering it. A dressing for the wound must next be secured. For fresh wounds nothing is better than soft or liquid grafting wax. A mixture of clay and cow-dung is the second choice, with shellac and paint to choose from if neither of the preceding materials is at hand. Tar should not be used, as it frequently kills the cambium it is supposed to protect.

In preparing the wound for the dressing all detached bark must be cut away with a sharp knife, care being taken to cut into the wood as little as possible. The dressing should be flowed on with a soft brush, or smeared on in such a way as to disturb the moist surface of the wood as little as possible. In two or three weeks it will be easy to see whether the operation has been successful. The surface will have grown outward perhaps an eighth of an inch, and scratching will disclose a pulpy greenish layer spread over it. It will not of course be present where the wood itself has been scraped or bruised. The cambium can be saved in this way with most uniform success in the growing season.

If the bark wound has not been attended to at once it should first be inspected to see whether any part of the cambium has escaped drying out and has started growing a new bark. Such areas should of course be preserved, unless they are detached tongues of the kind which has been described as being too remote from the line of sap flow. In that case they had better be removed, for they retard healing more than they help it. The first thing to do with an old bark wound is to clean it up thoroughly. Clear away all dead and shredded bark. Sound the exposed wood with a chisel or by boring into it, if necessary. If the wood is much decayed it may have to be filled in one of the ways to be described in a later chapter. A depth of decay of only an inch or two, however, or perhaps three or four inches, if it is a large wound, needs only to be cleared entirely away. If the resulting excavation extends under the sound callus at any point, the callus must be cut back correspondingly or the hole must be filled. However, a healthy callus will bridge or fill up quite a deep wound, provided it be so thoroughly painted or tarred that no decay or boring insects can get at the wood.

In the case of very large bark wounds, where, perhaps, the wood is checked and here and there invaded by borers, and it is evident that the tree cannot heal over the wound in many years, it should either receive repeated coats of a very heavy dressing, reinforced, perhaps, with cotton padding, or it should be covered with zinc. If the last course is decided on, after the wound is cleaned and trimmed up the zinc is cut to fit it, a paper pattern usually being made first. The zinc should preferably come up rather close to the edge of the wound, but should in no case overlap in the least the cambium or the bark. Having the zinc ready, paint the wound thoroughly, the back of the zinc likewise, and nail the zinc in place with shingle nails an inch or two apart. Its outer surface must then be painted, an especially heavy coat being flowed over the edges to make sure that they are water-tight. Thin sheet copper also does very well for this kind of work. The use of sheet metal will be described more fully in a later chapter.

A slightly different class of wounds is caused

Oak tree with large bark wound. The decayed bark has been cleared away and the sound wood has been creosoted and tarred

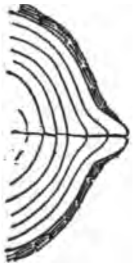
by the tree's growing against objects which do not give way before it, with the result that the bark is killed locally, or at least fails to make any growth. Such wounds are made by the plank seats which are frequently seen pried in between two trees. Both trees are sure to be injured sooner or later if the plank is not taken out every few years and cut down a little. In such cases if the compressed bark is dead it must be removed. If not, it should be cleaned off, so as to be free to grow. The tree which has had wires wound around it, or at least stapled to one side, is another frequent patient of the arboriculturist. The danger in such cases is that the wire will girdle or partially girdle the tree. All wire must be pulled out if the bark has not actually closed and joined over it. Of similar character is the tree which has outgrown its wire guard. If parts of the guard have become imbedded in the trunk, they need not be removed if such a course would require cutting the calluses closing over them. The bark of the meeting calluses should be pared down and perhaps slit in places, to encourage their growth. If the tree is vigorous and the calluses are scraped occasionally, they will ultimately grow together organically and permit the free flow of the sap down the cambium.

Another kind of bark wound is caused by the rubbing together of two limbs. Something more than mere local treatment is required in such cases. The best way is to cut off one of the limbs. If that cannot be done they must be braced apart in one of the ways suggested in the chapter on bracing. In addition, the worn places require thorough wound treatment.

The breaking off of branches is another frequent cause of wounds. When proper pruning and bracing have been neglected, large limbs of red and silver maples, linden, and such soft-wooded trees, are often fairly torn out by the roots. The thing to do in such a case is to clear away completely all splintered wood and torn bark. The essential thing is to prevent the possibility of any cracks remaining in which water can stand and decay begin. The smoothed surface must receive an especially heavy dressing. If it is large and at all cracked it had better be covered with sheet metal.

This last type of injury comes, so to speak, in all sizes, up to the huge wounds one so often sees, made by the tearing apart of a forked maple or elm. These are very serious affairs and require painstaking treatment in order to prevent the entrance of decay. The part of the wound requiring the greatest care is the lower part, the stub, it might be called, of the broken half of the tree. If the bark and wood of the stub have been split from the rest of the trunk, they will almost certainly die and permit the entrance of fungi and borers, no matter how effectively these may have been excluded from the upper part. The detached wood must be chopped or sawed away, so as to make a good water-shed, and so as to make it certain that there is healthy bark, in connection with the rest of the bark of the trunk, around every part of the wound, ready to start a callus over it. Of course it is not to be supposed that so large a surface will be grown over, at least for a very long period of years. The covering given the exposed surface should therefore be a thorough one, of metal or reinforced asphalt. Large surfaces of metal on bending trees have a tendency to tear out at the nails, a tendency, however, which can be partly remedied by putting the metal on in vertical strips overlapping each other.

Frost cracks and the effects of lightning will also be included in this discussion of mechanical injuries, for they are like the truly mechanical ones in result if not in cause. Frost cracks are fairly common, but their origin is not generally understood. The cracks first come to the notice as long but very narrow openings lengthwise of the trunk or main branches. After one or two seasons they usually develop long, narrow, light-colored projecting lip-like calluses on each side of the crack. These calluses grow and project farther and farther from the trunk as the years pass, unless a series of mild years permits them to grow together. The cracks are caused by sudden cold snaps which very suddenly freeze the outer layers of the sapwood while the heartwood is still comparatively warm on account, frequently, of its connection with the lower and warmer parts of the soil through the taproot of the tree. Freezing a wood cell draws the water out of the cell wall and collects it in a crystal in the center of the cell. When this happens the cell wall has to contract. If, in a cold snap, the periphery of the trunk contracts suddenly, before the inner part has time to cool and contract proportionately, something has to give way, and a frost crack is the result. After the crack is once formed sap flows into it, and, freezing, enlarges and perpetuates the opening. Bark pressure being removed from the contiguous cambium, it is stimulated to greater than ordinary growth and soon develops "lips." Frost cracks should be attended to promptly, for they are frequent sources of infection. If the injury is discovered soon after it occurs, the crack should be painted with liquid grafting wax, and if possible filled with grafting wax or cotton batting dipped in hot tar or asphalt. When calluses form their union



Cross-section through three-year-old frost-crack should be facilitated by lightly scraping their approaching surfaces in spring. In extreme cases, if unsightly lips have been formed which offer no hope of ever growing together, the entire ridge can be sawed off and the wood covered with a strip of sheet iron. In most instances it will be enough if a dressing (but not an unsightly one) is kept over the crack in order to keep out fungus spores. The cracks open in very cold weather, and that is the best time to put in fillings or to apply dressings. Scraping the bark increases the liability of a tree to suffer from frost cracks.

Lightning and other electrical phenomena affect the trees in many different ways. Lightning often smashes a tree all to pieces. Usually, however, it breaks a few branches out of the top and then passes down the trunk to the ground. As the moister parts of the tree are the best conductors, the electricity almost invariably takes its course down the cambium and the wet sapwood just below it. The course is usually rather narrow, oftenest three or four inches wide, though sometimes there are two or more such courses down the trunk. The wood offers sufficient resistance to the electricity to produce a high degree of heat. This heat instantly vaporizes the sap and it is the pressure of the steam thus produced which rips the long ribbons of bark and splinters of wood out of the trunk. The only thing to do with these long scars in the tree is to clean them of frayed and isolated bark and loosened wood and to paint them.

There is no certainty, after all, that this treatment will end the story, for lightning affects trees in strange ways. In some cases physiological injuries accompany the physical ones and cause immediate or gradual death. Again, a tree will be killed by lightning without the infliction of any physical injury. In still other cases, trees standing near a tree will succumb with it, although apparently unhurt.

Dr. G. E. Stone, in a bulletin of the Massachusetts Experiment Station, says that more frequently than they are severely shocked, " trees receive only a slight discharge, which burns out a small hole near the cambium, and the result of such a discharge will not be noticeable until two or three years afterward. In such a case a ridge forms on the bark, revealing the path of discharge. An examination of the tissue will disclose a small hole, usually not larger than the head of a pin, running down near the cambium layer. A wound even of this size acts as a stimulus and induces a marked growth of the cambium. These cases are very common but often overlooked."

In another bulletin Dr. Stone describes and illustrates the effect of " earth discharges " through trees. The cases he cites are largely localized, and he thinks the nature of the soil may bear on the phenomenon. The discharges are said to take place during thunder-storms, and to be accompanied by dull reports. Only a part of the tree is affected, as one side of the trunk and the adjacent lower limbs. The limbs may not be killed, even though split deeply. In a year or two creases appear on the trunk, marking the course of the discharge. "A very much larger number of trees than people are aware of show earth discharges." I have observed very similar injuries as the result of twisting strains upon the lower parts of limbs by the weight of snow and ice.

CHAPTER IV

BORING INSECTS AND THEIR CONTROL

IN view of a prefatory statement to the effect that this book deals only with the physical repair of trees, and does not concern spraying, it may surprise some that it should contain a chapter on insects. There are, however, a large number of very active insects, the bark and wood borers, which cause injuries very similar to mechanical injuries. They are treated with steel tools and with dressings in much the same way that wounds are treated, and the tree repair man is usually expected to attend to them.

No observing person who has had an intimate acquaintance with trees for any length of time need be told of the immense damage these insects cause. Others may gain some conception of it from the fact that conservative estimates place the annual loss attributable to forest insects in this country at $100,000,000 a year, of which the lion's share is caused by the borers. In certain instances the seriousness of this damage is brought home to us with special force. Fifteen or twenty years ago, to cite a familiar case, the black locust was hailed as the great post- and tie-producer of the future. To-day, in most parts of the country, hardly a sound stick of it can be found. The locust borer has made the growing of locust timber unprofitable — almost impossible.

The damage done to shade trees by these insects is greater, in proportion, than that suffered by forest trees. The reason is that almost all of these insects prefer to attack weak trees, and changing conditions have unfortunately so affected our town and city trees that a very large part of them are to a greater or less extent invalids. They no longer make the vigorous growth they made before streets were paved and fields were drained, and before factories poisoned the air. But if they are more susceptible, they are also more valuable than they were, and we must make every effort to save them.

It is neither possible nor desirable, in a book of this type, to enumerate and describe the many species of insects which in one way or another do physical damage to the trunks and limbs of trees. The bibliography which will be found in the appendix is sufficient evidence of the amount and availability of the literature bearing on the subject. The number of injurious insects found in a single locality may be very small, but the number of species injurious in one place or another throughout the country is so very large that a complete account of them would be more confusing than helpful to the average reader. I shall therefore describe only the principal classes of insects damaging the bark and wood of trees, illustrating the habits of each class by a brief account of its more important members. Suggestions for preventive measures will be correlated with the life histories, the proper adaptation of operations to the seasonal changes of the insect being all-important in this kind of work.

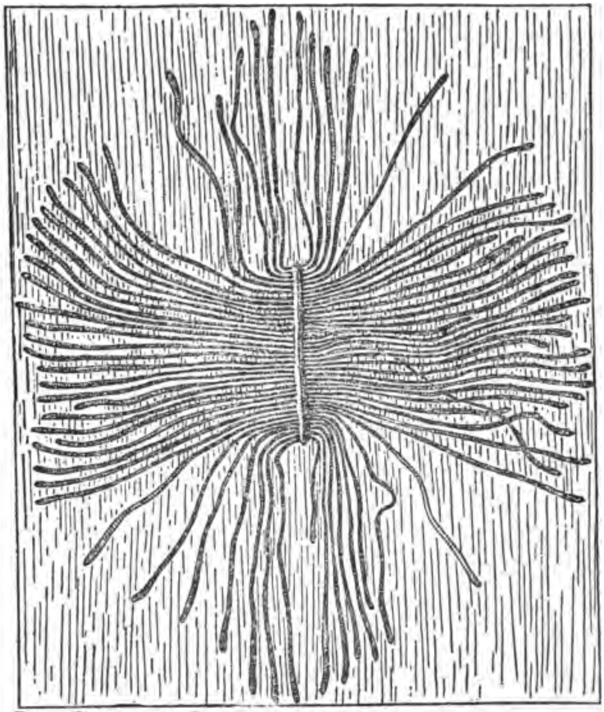
Almost all damage done by insects to the bark and wood of trees is done by them while they are in the larval or grub form. As is universally known, insects assume two distinctly different shapes during their lives. During the first part of their existence they are highly specialized for the consumption of food in large quantities and for rapid growth. That growth completed, after a longer or shorter period of dormant transformation (the pupal stage), they come forth in the adult, usually winged, form, especially adapted to reproduction and the wide distribution of the species. It is the voracious grubs which damage our trees.

Broadly speaking, the insects we are at present dealing with can be divided into two classes, according to the part of the tree in which the larva feeds and lives. There are bark borers and wood borers. The bark borers are most dangerous; the wood borers are perhaps most widely distributed.

The insects which do harm to the inner bark and outer sapwood belong (as do most of the heartwood borers) to the order Coleoptera, or beetles, distinguished by their hard "sheath-wings" covering the pair which are used in flight.

First among the beetles come the weevils, or snouted beetles, a race which devotes its attention most largely to fruits and stored nuts and grains. Half-a-dozen representatives live in the bark of trees. The cypress weevil mines in the bark of injured bald cypress, and the walnut weevil is at home in the inner bark of dying walnut trees.

Much more destructive are the bark beetles, or "shot-hole borers" as they are often called, in reference to the little round black-edged holes which they make as exits from the tree. Most of them make beautiful seaweed-like markings upon the surface of the wood, just beneath the bark. The most notorious member of the family is the hickory bark beetle, a stumpy, shining black or reddish-brown citizen, hardly more than an eighth of an inch long. The adults are common during the summer, feeding on hickory twigs. The eggs are laid in the limbs or upper trunk of the tree. The insect excavates a vertical tunnel an inch or two long, just under the bark, and along the sides of it, rather close together, it deposits the eggs.

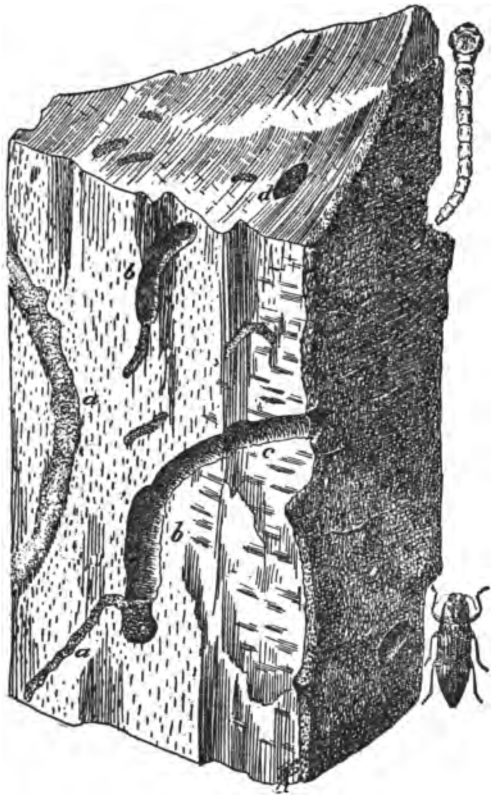


From Circular 144, Bureau of Entomology

Brood galleries of the hickory bark beetle on surface of wood

The young grubs strike out and excavate narrow but widening galleries at right angles to the primary burrow or radiating from it. They hibernate in these galleries, pupate in spring, and issue forth as beetles in May. Obviously, then, the bark of affected trees should be burned, and that of endangered trees should be given protective dressings, by May Day. A much smaller beetle of this race infests the oak, but in its case the primary gallery is horizontal, so the brood galleries are vertical. Still another infests wild cherry trees; another, elms.

The next family, though it signs itself the Cerambycidæ, is more often spoken of as the round-headed borers. The adults are long-horns, the slender antennæ being mostly longer than the body. Almost all of them are borers. One is the destructive common elm tree borer, the adult of which is a flat brown beetle half an inch long, with red-bordered wing covers. The grub is flat and white, and makes a long, irregular burrow. It hibernates as a grub in the tree, emerging about the middle of April or later. Better known is its relative, the locust borer, which works in the wood as well as the bark. The adult is a black or brown beetle, marked with bands of golden yellow. It is commonly seen munching pollen on golden-rod tops in September, at which time it lays its eggs. The grubs live in the bark during the fall, hibernate there, and burrow into the trunk, from which they emerge late in summer. Infested locust wood cut during the fall or winter must be burned, used, or immersed before the following Septem-



From Department of Agriculture Yearbook, 1910
Work of the flat-headed sycamore heartwood borer

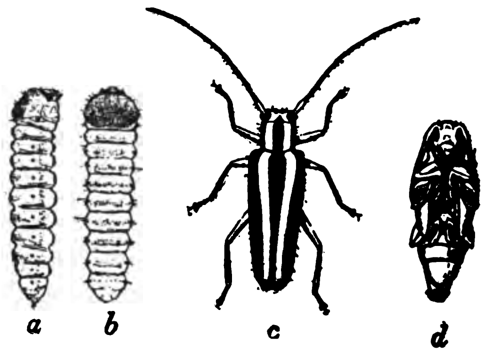
ber. If the grubs are to be dug out, the work should be done in the fall, before they enter the wood. The Bureau of Entomology has found that the hibernating grubs can be killed by spraying the trunks with a kerosene emulsion containing twenty-two per cent. of kerosene.

Many other members of this division are of sinister repute. Their very names brand them villains — the "sugar maple borer," the "poplar girdler," and the "linden borer." Still another is the round-headed apple borer, destroyer of apple and quince trees. The striped beetle appears in June or early July, and lays its eggs, soon after, as near as it can to the ground. On this account protecting the base of the tree for a couple of feet, and whitewashing the upper part of the trunk, form an effective protection against its attacks. Finally, though hardly in place here, is the broak-necked Prionus, a huge white grub burrowing into the roots and crown of apple, oak and aspen.

The flat-headed borers are also beetles, of the family Buprestidæ. Three of them are especially injurious. The bronze birch borer, an immigrant, has almost exterminated the birch trees in several cities, and also affects willow and poplar. Injury can be detected by a reddish discoloration a quarter of an inch to an inch in diameter, caused by exuding sap and ejected excrement, by the dying of the top of the tree, and by a wavy appearance of the bark. The galleries, just beneath the bark, are an eighth of an inch wide and hopelessly tangled and irregular. The adult beetles come forth in June and all infested wood should be burned before that time. Excision is practicable during the early stages of the attack. Preventive dressings should be put on the trees late in May and kept on for two months. A close relative of the birch borer, the sinuate pear borer, is destructive in some eastern states.

Another flat-head, the two-lined chestnut borer, is effectively helping the chestnut bark disease to kill out the American chestnut. The beetle is black, with two faint lines on its back, and perhaps three-eighths of an inch long. The larva is twice as long, and white, with a touch of brown at each end. The mature insects appear in May and June. Infested wood must be barked (and the bark burned) by the first of April.

Insects which burrow simply in the wood of the tree, not consuming any large part of cambium, are not nearly so damaging to the tree as most of the bark borers. Only a few species are likely to be the objects of genuine campaigns. Many of them, however, come to notice rather often in the work of tree repair because of their presence in decayed trees. Typical of the whole tribe is the flat-headed apple borer. Its larva, remarkable for its disproportionately large head, bores irregular mines in the sapwood of the apple and many other deciduous trees. The eggs are laid in June or July, and the insect is not so small but that wire netting is effective against it. Protective coverings should be kept on during the period suggested in speaking of the bronze birch borer. The flat-headed borers do immense damage to coniferous forest trees, causing, for instance, the

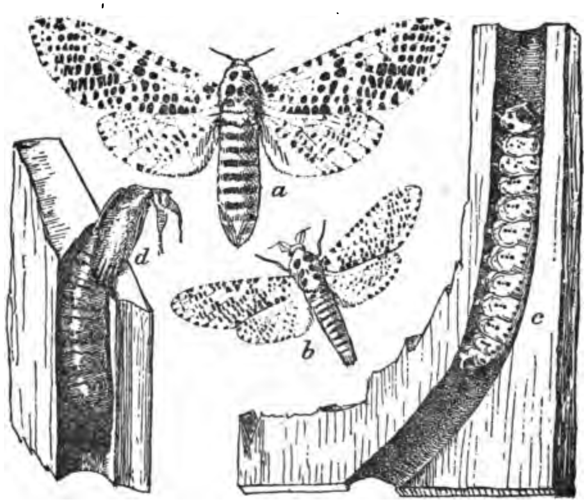


Round-headed apple tree borer, a, larva, from side; b, from above; c, female beetle; d, pupa

oval holes so common in cheap shingles. One or two infest sycamore, oak and beech.

Besides the flat-headed borers, the insects feeding mainly on the wood are the timber worms, the carpenter worm, and the horn-tails. Of the first group, the chestnut timber worm is the most important. It is responsible for the holes so commonly observed in chestnut lumber. There is little to be done with it directly, but preventive measures, as the destruction of dead and dying trees and limbs, are effective.

First among the carpenter worms is the leopard moth, introduced from Europe some thirty years ago. Many trees, fruit and shade, are attacked by it. The larva, which reaches a length of two inches, is yellowish or pinkish, with a dark spot



Circular 109, Bureau of Entomology

The leopard moth, a, adult female; b, adult male; c, larva; d, empty pupal

at each end. It is sparsely hairy and covered with prominent tubercles. The moths are hairy, with semi-transparent white wings dotted with dark bluish or greenish spots. They appear during summer, beginning in May. The eggs are laid soon after, and the young grubs burrow into a twig or branch. When they outgrow this first branch they migrate to a larger one. They frequently girdle a branch by burrowing around its circumference just under the bark. The position of the burrows is indicated by the matted sawdust at their mouths. Pruning affected small limbs is beneficial, on account of the grub's habit of migrating. Fumigating with carbon bisulphide and killing with wires also have their value. The larvæ live two years, spending the second year in the large limbs and trunk. A campaign against them should include one treatment of those parts of the tree in the late summer of two successive years.

The last group of insects worthy of mention as wood borers is the horn-tail tribe, or wood wasps. The commonest species is the "pigeon tremex." The adult is a large, stocky, wasp-like insect, with two pairs of transparent brownish wings. The body is brown with lighter bands across the abdomen, at the posterior end of which there are in the female three stout spines, used in depositing the eggs in the bark. The larva is stout and cylindrical, with a small head. The adults emerge in summer and lay soon after. The burrows of the grubs and the holes made in the bark by the escaping insects are round, and nearly a quarter of an inch in diameter. The insect does not do great damage on account of the small amount of cambium it destroys. The only measure which can be taken against it is the destruction of infested trees. The main reason for describing it here is to prevent confusion of this insect with a beneficial parasite upon it which is often blamed for the work of the tremex. The parasite is an ichneumon fly, *Thalessa lunator,* which slightly resembles the tremex in appearance, though the ovipositor of the female, instead of being half an inch, is three or four inches long. The male has a slender abdomen, and both have dark spots on the first pair of wings. The *Thalessa* deposits its egg in the burrow of the tremex, and its larva causes the death of the tremex larva.

Such are the principal insect enemies of trees with which the tree repairer is likely to have to deal.

All these pests must be fought relentlessly, and it is the duty of the local government, and at times of the State and National Governments, to lead in the fight. The best line of campaign is prevention, and effective preventive measures must usually be undertaken on a larger scale than is possible to any but the largest private owners. Insomuch as most of these insects prefer, and increase rapidly upon, weak and dying trees, the authorities should see to it, in so far as they have power, that dying trees are removed and burned, and that weak ones are pruned and fertilized into vigor — or else that they go the way of the dying trees. Allotment companies are great sinners in this connection. They carry out grading and drainage operations which cause the death of hundreds of trees, whose bark and trunk are soon fairly alive with busy hosts of insects. People who buy lots in such vicinities must keep watch on their own trees, and should use their influence to have the sources of infection removed.

In addition to these measures, which are simply the application of good silvicultural principles to the trees of the city, considered together as a forest, it is extremely important that all trees, and especially trees of a threatened species, or trees in an infested region, should be kept in good health. In some cases fertilization alone will be found a sufficient check upon an epidemic of bark beetles. The most destructive species affect only weakened trees. The way to make them pass by your trees is to see that your trees have a good healthy flow of sap. That means "Water and manure!"

We have, then, these rules for the prevention of insect epidemics and attacks:

1. In planting, select trees suited to the soil and locality, so that they can easily be kept in a thrifty, resistant condition.

2. In the case of established, as well as newly planted trees, see that the soil is right as regards fertility and physical condition, and that the trees

have the proper amount of water. That is, keep all trees vigorous.

3. Cut and burn, or at least bark, all dead and, especially, dying trees not later than the first of April of each year, unless the habits of some particular pest indicate another season as the correct one.

Under certain conditions, however, especially in orchards, the use of a direct protective covering or dressing may be the only way to prevent an attack. These take several forms. Against the round-headed apple and quince borers and the peach borers, a covering of tough paper or fine wire netting, tied tight above and heeled two inches deep with soil below, make effective protections.

Of repulsive dressings there are a large number, though less often recommended now than formerly. "Raupenleim," for instance, sold by the Bowker Fertilizer Company, of Boston, is very effective as an all-over covering. Mixtures containing vaseline or tar should not be used in large quantities. The thinner applications, which depend mostly upon their smells for their effectiveness, have also much value, though they must usually be renewed at intervals during the summer. The best of them is probably a pound of whale-oil soap dissolved in a gallon of water and reinforced with two ounces of carbolic acid. The trunks and lower limbs of the trees should be painted with the mixture at intervals of two or three weeks during the danger season.

Similar in results, but unlike in the way they are attained, are whitewash and cement paint. Whitewash must be applied heavily and very thoroughly, the loose bark being previously brushed off. It must be renewed as often as the weather destroys its completeness of covering. Cement paint, made by mixing, to the consistency of heavy paint, Portland cement in skimmed milk, makes an extremely effective protection and lasts the whole season. It, as also whitewash, can be colored to suit the operator's fancy.

These campaigns must of course be planned in advance. Above all, the egg-laying season of the particular insect in hand must be determined. If doubt as to that point exists, consult the entomologist of your State Experiment Station, sending him a full description of the injury, and, if possible, specimens of the insect.

Preventive measures such as these, however, are not exactly tree repairing.

The only way to fight the borers after they have attacked a tree is to dig them out or kill them individually in their burrows. The work can be done at any time, but perhaps late summer and early fall are the best. The operator should provide himself with the tools ordinarily used in treating bark wounds. In addition a half-inch curved wood-carver's gouge will be handy. Some steel wire will be needed for probing the burrows. Different kinds of wire suit different jobs, sometimes a stiff, and sometimes a soft wire being the best. The materials required are putty, which is the handiest thing with which to plug up small holes, though some people prefer the more expensive grafting wax, carbon bisulphide for poisoning grubs in their holes, and the ever-essential paint or tar.

The attack begins with a careful study of the enemy's plan of campaign — determining whether or not more than one age of larvæ is present, whether, say, some burrows contain one-year larvæ and others two-year; discerning the signs, often very minute, which mark the presence of a burrow; and investigating carefully the direction and length of the burrow and the comparative effectiveness of the probing and poisoning methods of attack. If it is found that the burrow is large enough and straight enough to make it possible to kill the larvæ by probing the burrows with a wire, that method should be adopted. It is far the most rapid. After the hole is probed it must be plugged up with putty. If there is any dead bark about the entrance of the burrow (and many borers live for a time just under the bark before they enter the wood) it must be cut away and the wound must be painted.

If, on the contrary, probing the burrow is not rewarded by that peculiar and gratifying sound which makes known that the larva has been crushed, poisoning must be resorted to. Carbon bisulphide is almost invariably used for this purpose, because of its cheapness and convenience. It is a highly volatile fluid, giving off a gas which is deadly to all animals. It is inflammable, and he who smokes while he uses it had better look out for the fool-killer. As a rule, it comes in half-pint tins, stopped with a cork. There are several ways of applying it to the burrows. I carry around a pocketful of little bits of cloth, say an inch square. When I have opened up the mouth of a burrow I take one of these bits of cloth with a pair of forceps, dip it into the carbon, and then insert it in the hole, which is then, of course, immediately plugged with putty. The more usual way, though, is to apply the fluid with a small syringe, those of glass being handiest. About half a teaspoonful or a little less is required for each hole.

It is extremely essential, in going over a tree, that every burrow be found, and that the eye be trained to detect the least indication of the presence of a borer. Every suspicious-looking spot must be investigated, until the true signs are mastered. If the whole tree is infested and an effort is made, nevertheless, to save it, the trunk should be done thoroughly, whether there is time to do the limbs or not.

In his important work on forest insects (Fifth Report of the United States Entomological Commission, 1890) Prof. A. S. Packard describes a method of combating bark borers which had been tried, apparently with success, in Belgium. It was discovered that a full flow of sap killed the larvæ, doubtless the reason the insects prefer weak trees. Insomuch as removing bark pressure increases sap flow, particularly in spring, the experiment was tried of paring off the outer layers of the cortex, down to say a quarter of an inch or a little less of the cambium, over the affected areas in old elms. The resultant flood of sap killed the grubs. The writer has had no personal experience with this method. He would suppose that it would be hard to say just which trees and what parts of them were invaded by the borers until it was too late for the work to be effective. A protective covering of cement paint would probably be necessary to prevent undue drying of the exposed inner bark.

Such measures as this, and not less the usual curative operations, ought invariably to be supplemented by the use of stimulating manures.

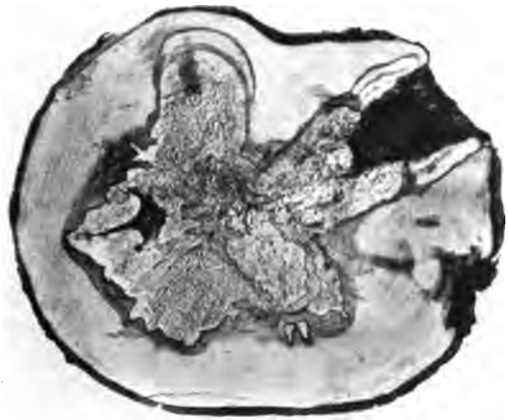
CHAPTER V

ROT-FUNGI AND THEIR WORK

HOLLOW trees are caused by fungi. If it were not for rot-producing fungi trees would live twice as long as they do, lumber would cost half as much, and this book would not contain half as many pages as it does. These fungi are plants of a low order, plants in which there is no, or little, differentiation into root, stem, and leaf. Every bacterium is a fungus; so is every mold, mildew, smut, and mushroom. The main respect in which these plants are alike is that they do not contain chlorophyll, the green coloring matter characteristic of plant cells which carry on the work of photosynthesis, or the utilization of the carbon in the air. That is, they cannot make carbohydrates out of water and carbon dioxide, as green plants do. The same is true of animals, and the fungi are like animals in that they are absolutely dependent for their sustenance upon materials elaborated by chlorophyll plants, either in the form in which those materials are produced by the plants or as they may be worked over by plant-eating animals. In other words, fungi live upon living or dead plants or animals. Those which subsist upon living organisms are called parasites; those which live on dead matter are saprophytes. This division, however, is not iron-clad, for some fungi part of the time follow the policy of one class and part of the time that of the other. Fungi which can live only upon the heart-wood of trees are of course really saprophytic, because the heartwood is dead.

Intelligently to prevent and as far as possible remedy the attacks of rot-producing fungi, it is essential that the man who is doing tree repair work should study and understand their manner of growth and distribution, and should be able to distinguish the most important species, just as a good physician must know all that has been discovered about typhus and tuberculosis bacilli.

The life cycle of a fungus is superficially quite like that of one of the higher plants. The mushrooms and hoof-like or shelf-like growths we see so often on dead and decayed trees are the fruiting bodies of rot-producing fungi. From their lower surfaces come thousands of little dust-like cells, called spores, which have the capacity of vegetating like seeds and of growing into new fungus plants. Let us suppose that such a spore, from the fruiting-body of the "white heart-rot," is wafted away by the wind and falls upon an old bark-wound in the trunk of a maple, the surface

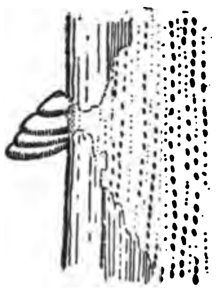


Cross-section of maple affected by white heart-rot

Cross-section of oak showing work of *Polyporus sulphureus* (Bureau of Plant Pathology, Bulletin 49)

of which is now checked and weathered and moist. Here all the conditions are favorable, and in a few days the spore begins to grow and sends out a minute root-like organ containing living protoplasm. This hypha grows and branches and soon makes up quite a mass of fibers, gradually working its way into the heart of the tree. The hyphæ, considered together, are called the mycelium of the fungus, and really constitute the fungus plant. The brackets and mushrooms which appear on the outside of the trunk are special bodies — in a way, fruits — developed by the plant solely for the production of spores, and called, on that account, sporophores. The living tips of the hyphæ make their way through the wood in various ways. Some work in between the cells, sending little root-like branches through the walls of the cells to suck out what is nourishing of their contents. In other cases the tips of the hyphæ exude ferments which dissolve the cell walls and permit the hyphæ to grow freely throughout the wood, consuming part of it and leaving the rest fragile and disunited.

Although the hyphæ of the fungus are quite invisible to the naked eye, the result of their work is easily detected. The wood changes in color, texture, and weight. These changes, however, are to a large extent gradual. In the case of some fungi it is very difficult to draw a line in a cross-section of a rotted trunk, between the diseased wood and the sound wood. Sometimes the wood is discolored before it is actually invaded. In other forms, the wood is invaded a considerable distance before any change is observable to the unaided eye. When a fungus is working up a tree, also, it often sends an advance guard of mycelium up the very center of the trunk, where the soft pith makes its progress easy. All these facts make it much more difficult than it would otherwise be to make a complete excision of decayed wood.



Section of a decayed trunk, showing relation of sporophore to decay

As regards the rate at which decay spreads through wood, but little is definitely known. It is certain that different decays grow at different rates, and that the same decay spreads at different rates in different trees. The indications are that, in the main, decays spread very slowly — sometimes only a little faster than the wood is built up by the cambium.

After the passage of a greater or less period of time, often amounting to many years, a denser mass of hyphæ than usual gathers at some point near the outer surface of the host, usually at a wound, a rotted knot-hole, or the burrow of a boring insect. From this mass there is sent out a more or less highly differentiated and completely formed body, the purpose of which is to develop and disseminate the spores. The appearance of sporophores on a tree is of course conclusive evidence of the presence of decay within the tree, and usually a large amount of decay, for the fruiting bodies are not produced until the fungus plant has made a strong growth. In certain cases sporophores are not produced until the mycelium has exhausted the available supply of nourishment. Frequently a fungus subsisting in a living tree does not send out sporophores until its host dies. The moral is, not to suppose, just because there are no mushrooms on your trees, that there is no decay inside of them.

The many hundred rot-producing fungi affecting living trees fall readily into four groups, according as they attack mainly the bark, sapwood, heartwood, or roots. For the present purpose it will be enough to describe one or two of the more important members of each group. Readers who desire fuller information are referred to the bibliography.

Of bark decays the commonest and best known are the apple bark rots and the chestnut bark disease. There are a number of fungi which kill larger or smaller areas of the bark on apple limbs and twigs. Several of them, as the bitter rot, also attack the fruit. The apple blister canker (*Numularia discreta*) is one of the most destructive. It is a wound parasite, starting growth wherever a bit of dry wood presents itself. For a time it grows in the heartwood, then spreads into the bark, rapidly killing a large patch. The affected area becomes brown, sunken, and blistered. In a year or two the branch is girdled and killed. Pruned orchards should be sprayed promptly with a fungicide, and all large wounds should be dressed with an antiseptic. Small branches which are inoculated should be removed. On large limbs the affected areas should be cut away with a draw-shave, the wound being carefully dressed. The man who is repairing trees must know the apple bark rots. When he finds a tree seriously affected by one of them he must not fuss with cavities in the tree until the far more dangerous bark rot is cleaned out.

The chestnut bark disease is not unlike the blister canker. The mycelium of the fungus enters the bark through small wounds. It grows in the bark and cambium, spreading until it girdles the limb and starves the outlying parts. The bark of the affected areas becomes light brown and shrinks as it dries. This fungus is spreading rapidly in the eastern states. Many of the state forestry departments, as well as the National Government, have issued bulletins on the disease, directing owners of chestnut timber as to the way to handle and use affected trees. There is no wholesale method of combating the disease.

Valuable trees can, however, be treated individually. In an interesting article in the February, 1913, *American City* Mr. R. G. Pierce describes his system of treatment.

"All the diseased bark or wood must be removed from the tree and burned. The tools, such as gouge, chisel, knife or hand ax, used in this cutting-out work, as well as the cut surface, should be thoroughly sterilized. The wound after sterilization should be covered with some water-proofing. . . ." Mr. Pierce goes on to describe his method of operating in detail. Small branches which are affected he removes with a sterilized saw. Diseased areas on larger limbs he cuts out, cutting into the wood a depth of five or six annual rings, and removing at least an inch of healthy bark around the discolored area. Tools must be sterilized (as by dipping in creosote) before the final layer of wood is removed. Mr. Pierce catches the diseased bark thus gouged out in a bag to prevent it from infecting lower branches in its fall.

The fungi of the next group, those causing decay of the sapwood, are probably in no case true parasites. When they attack living trees it is only very weak trees which are seriously damaged. They very quickly attack unseasoned timber, standing or felled. For instance, *Polystictus pergamenus* is frequently found growing on trees which have been seriously injured by fire, frost, or sunscald. It attacks the dead bark first, spreading later into the sapwood. In a few years it sends out hundreds of little shelf-like, leathery sporophores. The prompt cleaning away of every patch of dead bark and the dressing of wounds are the only preventive measures, and of course complete excision is the only cure.

The third group is the most important of all. Almost all its members are wound rots, entering the tree through exposed surfaces of wood. They make their way from the wounded spot into the heart of the tree, and grow up and down in the heartwood. The destruction of the heartwood is not immediately harmful to the tree, and some fungi cannot spread outside of the heartwood. Others, the majority, though they cannot actually invade healthy sapwood vessels, can work their way into the sapwood by virtue of certain changes, approximating a change into heartwood, which take place in the sapwood immediately contiguous to the decay. These changes take place most readily where the sapwood has become drier than usual, as through the death of a root just below it, or the removal of the bark covering it. Thus the fungus can work its way to the surface at a wound or weakened spot, and push out sporophores. The invasion of normal sapwood by heartwood rots is, however, very slow, and it almost never happens that a tree is strangled and killed by such a fungus. What the heart rots do is to weaken the support of the tree, making it liable to destruction by storms.

Perhaps the commonest and most destructive of the fungi inhabiting the heartwood of trees is the "white heart rot" (*Fomes igniarius*). It is found in every part of the world. In this country it most frequently attacks beech, aspen, willow, maple, walnut, hickory, apple and oak.

Entering through wounds or the stubs of dead limbs, the fungus attacks the heartwood of the tree. Von Schrenk and Spaulding give the following description of the effect of the fungus upon the wood of the tree: "The diseased wood is very sharply bounded from the healthy wood by black layers about one-eighth to one-sixteenth of an inch in width. There may be but a single one or there may be several arranged more or less concentrically. Just outside of these layers there is a layer consisting of from three to six annual rings, which is darker in color than the normal wood because of the infiltration into the same of products of the decomposed wood. . . . The black layers never exactly follow the annual rings of growth. . . . The completely rotted wood is white to light yellowish in color, according to the species of tree in which the fungus is growing. When rubbed between the fingers it breaks up into fine flakes, but does not powder."

The fungus does not normally develop sporophores until many years after infection. The woody fruiting body, though somewhat variable in appearance, is usually hoof-shaped, with a hard outer layer, brownish or blackish in color. To the lower surface of the hoof there is annually added a gray or reddish-brown layer of pores in which are produced the spores which reproduce the fungus. The first sporophores usually appear at the point of original infection. Later ones may break out wherever the decay comes close to the surface of the wood. The sporophores are by no means so common as the rot. In many groves of infected trees not a single sporophore will be found.

A decay of which the sporophores of the causal fungus are more familiar than those of the fungus just described is the red heart rot induced by *Polyporus sulphureus*. It attacks both coniferous and deciduous trees, particularly the oak, chestnut, walnut, maple, apple, pear, and hemlock. Wood destroyed by this fungus becomes red-brown and full of checks, in all three planes, which fill with white sheets of mycelium. Later the powdery remains of the wood can be shaken out, exposing

Fruiting bodies of white heart-rot fungus on aspen
(Bureau of Plant Pathology, Bulletin 49)

the mycelial framework. Trees long affected are always hollow with masses of the powdery rotten wood, alive with insects, at the bottom of the cavity.

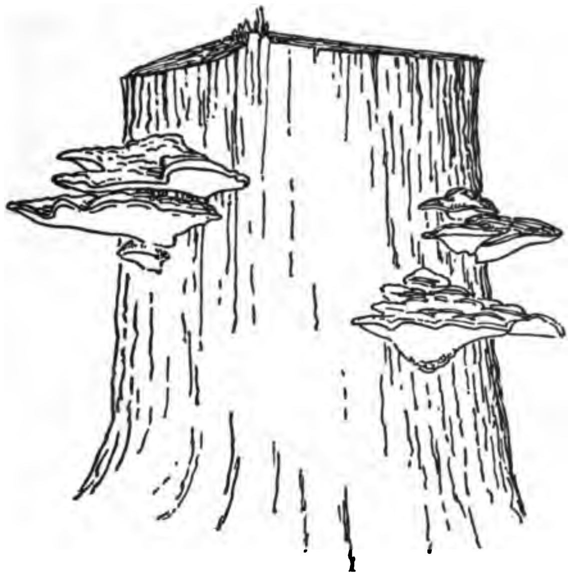
The mushrooms of the red heart rot, which are edible when young, appear in late summer but do not persist long.

Hydnum erinaceus, the "coral mushrooms," causes a decay of oaks and maples characterized by the softness and moistness of the decayed wood. "The diseased wood in its final stages," say von Schrenk and Spaulding, "is soft and mushy, so that when squeezed considerable water flows out. Trees in an advanced state of decay have numerous large holes in the heartwood, which are filled with masses of light yellowish, fluffy fungous mycelium." The mushrooms, much sought by epicures in that sort of delicacy, are lumpy, soft, moist-looking, and crowded underneath with spike-like teeth bearing the spores.

Root rots are fortunately not so common as heart rots, for they are at once deadly and almost impossible to combat. The only well-known species is the honey mushroom, *Armillaria mellea.* The fruiting bodies occur in masses at the base of the affected tree or on the surface of the soil above a large root. The individual mushrooms are rather small, honey colored, and specked with white. The stem has a swollen base and a ring around its throat. The gills are white. The honey mushroom produces growths sometimes called " shoe strings " which are commonly seen under the rotten bark of dead stumps, and in the surrounding soil. They are flat (in open soil round) black strands of hard-woven mycelium. It is at the ends of them that the mushrooms are found. The fungus enters through a wounded root, spreading into and killing the cambium, and progressing from root to root by means of the " shoe strings." When most of the roots have been killed up to the trunk the tree suddenly blows over. The rotten roots should be dug out if possible, and no new tree should be planted near by for several years.

In addition to these fungi which cause disease in living trees, there are two found only on dead trees or branches which are so common that they must at least be referred to. One is *Fomes applanatus,* the common brown and white shelf-fungus. It is found only on dead trees or dead parts of trees. The other is *Polystictus versicolor,* the variously tinted and striped papery little shelf-like sporophores of which are omnipresent in the woods and along the railroad track. It attacks but one tree in the living state — the catalpa.

Below wounds and in the vicinity of cracks in elm, maple, and horsechestnut trees there is often seen a whitish or brownish stain, caused by slimy exudations from the cut or fractured wood. Such a flow is called a slime-flux. The flux is characterized, in addition to its appearance, by a sour,



Sporophores of *Fomes applanatus* on dead maple stump

yeasty smell. Slime-fluxes are probably due to the growth of algæ, low fungous forms, as bacteria and yeast, and often animalcules, in the sap which escapes naturally, at the time of the original injury to the tree, from the cambium and sapwood. The growth of these minute organisms causes the formation of a slimy covering over the exposed wood. This covering is of a liquescent nature — attracting water. It thus draws the watery sap from the sapwood, preventing the natural drying-out and closing of the sap-conducting tubes. The process continues for an indefinite period, until the cambium in the vicinity of, and especially below, the source of the flux is killed. It, and later the inner bark, turns brown, and the bark is easily separated from the wood. The deleterious effect of the flux upon bark tends to prevent the healing, by calluses, of the wound, and contributes further to the permanence of the flux, which usually continues until higher fungi invade the area and kill the wood from which the flux had been drawing sap. This is a rough and ready account of a phenomenon scientists are still studying, but it will do for our purpose.

The disposition of wounds to be affected by slime-flux can be diminished by pruning in the dormant season and by dressing wounds promptly with a penetrating antiseptic such as creosote. Curative measures must of course be carried out in the dormant season. If it is a flat pruning wound scrape the cut surface and pare away all dead bark. Then apply hot creosote or hot tar, following later with a second coat. If the flux exudes from a hole, clean out the place with a gouge, making the excision a thorough one. Then treat the cut surface as just suggested, preferably drying out the hole with a gasoline torch beforehand. Do not fill such a hole until the success of the cure is certain. If the trouble arises in a crack which cannot be gouged out, the only things to do are to make the drainage as good as possible and to spray the crack often with a copper solution.

There seems to be no better place than this to throw in a reference to mistletoe, which is a serious pest in some parts of the South. When possible the infested limbs should be removed. Attempts to prune off the parasite, or even to gouge out its roots, are not often successful.

CHAPTER VI

THE VALUE AND FUNCTION OF FILLING TREES

AFTER finishing this chapter some readers may think that the writer is like the doctor who, as a physician, gave his patient some medicine, and then, as a friend, advised him not to take it. But he will not plead guilty to such a charge. He believes that "tree surgery" has a function and real value, but he thinks there are limits to that value, and this chapter, roughly speaking, is an attempt to define those limits.

The first thing to be admitted, or stated, is that the art of filling cavities in trees is still in an experimental stage, the value of the work, and even the right ways of doing it, being as yet quite uncertain. This statement may shock some people who have seen fillings done by the better workmen, and who have read or heard the claims of the "tree surgeons." Yet with that statement nearly every experienced arboriculturist in the country will agree, and it is a statement which can be proved.

To begin with, we must study the effect of decay on trees when the tree repairer does not interfere. One of the most surprising facts about the normal course of decay is the extreme slowness with which it does its work. This will be branded as the rankest heresy by every "tree doctor." They have made every effort to create the impression that the least sign of decay, if untreated, will be followed by speedy dissolution and certain ruin. But the proof is all on the other side. Common observation and the records of history and science, all agree that perfectly hollow trees frequently survive and flourish for very long periods. Literature and legend are full of references to such trees. No one who has gone back to the old farm of his youth has failed to recognize many of the "bee trees" and "coon trees" and "old hollow apple trees," which were seemingly no more hollow than they had been a decade or two before. In 1687 the Charter Oak contained a hollow large enough to hide the charter of Connecticut in. If there had been tree doctors in that day they would have affirmed that only a prompt filling of concrete would prevent the early death of the tree. Yet not until 1856 did it succumb, still green, to the storms of New England.

The trees themselves, in many ways, offer evidence of the time decay may continue without being fatal. A tree makes an effort to close a wound by rolling a callus over it from the sides.

If a cavity develops where the bark has been wounded, the callus has no support, and as it grows it does not bridge over the cavity, but simply rolls inward, gradually becoming a great fold. Insomuch as the fold increases, like other wood, by annual layers, it is easy to count or estimate, in a cross-section through such a fold, the number of years since the tree became hollow. Folds of this kind are not infrequently found to be half a century old, or even a century.

We can even look at the teeth, so to speak, of of the rot-producing fungi themselves. Many of these fungi have a woody fruiting body, or sporophore, which adds to itself each year a new layer of spore-bearing tubes. The number of layers therefore indicates the age of the sporophore. The hoof fungus *Fomes igniarius,* is such a one. Sporophores of the hoof fungus have been found which contained eighty annual layers. And it must not be forgotten that the fungus may have lived in the tree many years before it produced a sporophore.

All these facts, taken together, conclusively demonstrate that the decay of trees is sometimes an extremely slow process, and all indications point to the conclusion that it is normally such.

"But," it may be objected, "tuberculosis is often a very slow disease. Is that, then, any reason for not trying to cure it?" Not by any means, but it is a very good reason for not too hastily concluding that the disease is cured by a certain treatment, just because the patient survives that treatment for a year or two. And that is just the point. The tree surgeons, if we express doubts as to the effectiveness of their work, will show us examples of it which are eight or ten years old, and ask if any further proof is necessary. It surely is. We must be convinced that the tree would not now be in as good condition as it is if the filling had not been put in. That, of course, is not an easy thing to do, because no two trees are alike, and because of the impossibility of seeing what is going on inside of a filled tree. No definite conclusion can be arrived at as to the effectiveness of large fillings in decayed trees until impartial observers have studied a large number of filled and unfilled trees for a long period of years. This conclusion obviously works both ways. If it will take a long time to prove that filling trees works, so will it take a long time to prove that it doesn't work, and the only way to learn is to try. With this the writer agrees perfectly, because it is an admission of his thesis, that tree surgery is still in an experimental stage.

There is one aspect of the filling of trees, however, about which doubt no longer exists, and that is its expensiveness. It requires a great deal of hard as well as skilled labor to remove the decayed wood from a rotting tree and to put in a filling of concrete or asphalt. When there are many trees, it is easy to see that the bill is likely to be a large one. Few would object to the cost, however, if paying the bill meant that the trees were permanently restored to health and vigor. Few would object if they were sure that, whatever the result, the money was spent in the way in which it would do the trees the most good. But not many of us have absolutely unlimited funds to expend on our trees, and we want to be reasonably sure, if we spend a hundred dollars for having a tree filled with concrete, that the tree will be helped thereby, and helped more than it would be by any other expenditure of the hundred dollars.

It is this condition of affairs which makes it so essential that the owners of trees, and the landscape architects and other professional men who are called upon to advise them, should be informed as to the principles to apply in determining whether a certain tree ought to be filled or not. As a help in that direction, certain rules can be laid down, but it must be remembered that they are not iron-clad, and that they are subject to the supreme rule that circumstances alter cases.

The first rule is almost self-evident, and it would not seem necessary to state it, if it had not frequently been violated by tree surgeons. It is that no expensive cavity work should be put into a tree belonging to a species which, locally or generally, is doomed to destruction by the attacks of insects or fungous diseases. In some parts of New England this principle would rule out work on old elms, on account of the havoc wrought by the elm-leaf beetle and the leopard moth. The rapid spread of the chestnut bark disease makes it almost foolhardy to put much money into chestnut trees within two hundred and fifty miles of New York. Even beyond that radius, it is doubtful whether work is admissible which looks forward fifteen or twenty years.

The second rule is to the effect that it is usually unwise to spend much money filling trees that stand in a grove or woods, where the mass of the foliage counts for more than the individual trees. In such a case the grove should be handled as a whole. Its effect as a whole, the thickness and the color of the foliage and the thriftiness of the trees, is likely to be improved far more by enriching the soil, by installing a watering system, or by planting young trees, than by the expenditure of the same amount of money in filling cavities in one or two of the trees. In this connection it must be remembered that in the absence of the elementary requirements of tree life, water and good soil, the other trees in the grove will one by one need more or less expensive doctoring. If a veteran of the grove becomes weak and threatens to succumb to the storms, prune it back severely, perhaps brace it to its stronger neighbors, fertilize it, and plant a young tree or two near by. The chances are good that the old tree will become a sturdy specimen and thrive for several decades. The young tree, in the meantime, will grow to fair size, and will be ready to take the veteran's place. If the grove is to be permanent it must always contain young trees as well as old ones.

In the third place, expensive fillings should not be put into trees in a region where there is a high mortality rate (either among all trees, or simply in the species to which the decaying tree belongs) on account of gradual changes in the environment. Such regions of high mortality are common near cities. They are oftenest caused by the lowering of the water level and the consequent drying of the soil, as a result of draining, street-paving, the destruction of the forest floor covering, and the compacting of the surface soil. They are also caused by the contamination of the atmosphere by factories. When such a state of things exists, or threatens to exist, it is obviously unwise to spend money on work which cannot in any way diminish the risk from the prevalent adverse conditions. If there is money to be spent upon the trees in such a locality, it should be spent, if at all, in an effort to restore the natural conditions for want of which the trees are dying, and preferably in improving the soil. Money spent on the soil is rarely wasted. If it does not save the old trees, it will at least give their young successors a good start in life. If the trees survive and adjust themselves to the new environment, the ones that require it can safely be filled or otherwise repaired.

The fourth rule is scarcely more than a special case under the last. A tree which has just undergone a distinct change of surroundings should not be filled. Such a change might be, for instance, the building of a house very near to the tree, with the resultant cutting of roots and branches, or the simultaneous removal of a number of close neighbors, or the installation of a drainage system. A number of years should be allowed to elapse in such cases, before the tree is filled, in case it contains a large cavity. Filling, which can in no way help the tree to meet the new conditions, should be deferred until it is certain that the tree will survive the change of environment.

Expensive cavity work should not be put into a tree unless the other needs of the trees have been, and are going to be, attended to. If a man is starving to death it does not lessen his misery to reflect that his bones are strong enough to support a fat man. Decaying trees can survive without fillings — even flourish without them — but no tree can long survive or flourish without food and water and protection from its insect enemies.

Nor should any tree receive costly surgical care if it is weak and making little growth. The great army of bark and wood borers and other insect enemies ready at any time to swoop down upon a weakening tree, makes the expectation of life of a weak tree very precarious. Common sense indicates that no large sums ought to be risked on sickly trees.

Again, only after very careful consideration should a hollow tree be filled up which has completed or nearly completed the span of life natural to that species in that climate and soil. Sometimes such old trees can be reinvigorated, but in every case the measures calculated to restore youthful vigor should be carried out and their success assured, before much filling is done.

Finally, from the fact that a tree is hollow it does not necessarily follow that a concrete or asphalt filling is "indicated," as the doctors say. Some decays eat out the entire heartwood and die out with the destruction of the affected wood. In such cases filling is of but little value. The decay has done its work and it is too late to stop it. The drainage of the cavity is usually good, and the inner surface is often so weathered that it is as resistant as a seasoned plank. Such a condition of affairs is often observed in old sycamores. No further treatment is justified than smoothing and painting the walls of the cavity and carefully bracing the tree. Equally futile is the attempt which is sometimes made to remedy chestnut trees which have been completely hollow by the powdery red heart rot.

These general rules for the avoidance of unwise expenditures in large tree repair projects must be supplemented by a discussion of the comparative importance of various kinds of cavities, and a classification of them with reference to ease of execution and certainty of success.

As a preliminary of such classification, however, we must formulate a statement of the ends aimed at in the filling of cavities, because our decision as to the probability of success in filling each type of cavity will depend upon the degree to which the purposes of the filling can be attained under the peculiar conditions presented by that type of cavity. Briefly stated, holes in trees are cleaned out and filled with these three purposes in mind: First, to stop decay by removing all the fungus. Second, to prevent the entrance of fungi and insects by coating all exposed wood with a protective dressing, by filling the cavity with cement or asphalt, and by facilitating the healing of the wound. The third purpose is to strengthen the tree.

These different purposes are attained with varying degrees of success. The first purpose can sometimes be attained perfectly, especially in cases of limited and local infection by a fungus which produces a definite line of demarcation between the sound wood and the diseased. At other times it is absolutely impossible of attainment, and is frequently impossible at a reasonable cost. The second intention is subject to about the same chances of success, depending upon the kind of tree and the shape and location of the incision. As regards the third purpose, it may be said that fillings add little or nothing, of themselves, to the strength of the tree. The iron braces usually put in to hold the filling in place, however, have some strengthening effect. But this phase of the work will be taken up in greater detail in the following chapter.

These are the things that the tree surgeons do, but they are not, it is true, the only things they claim to do. They have been able to create in people's minds the impression that filling a tree constitutes an immediate relief from some sort of canker which saps the life of the tree, and that the process of filling exerts a direct physiological influence, at once increasing the tree's vigor and restoring, so to speak, its good spirits. This kind of talk has caused the breach which undoubtedly exists (and much to the detriment of the real science of tree repair) between the tree surgeons and the arboriculturists and landscape architects.

A gentleman whose knowledge of plant physiology was gleaned from the booklets of tree surgeons, once said to the author, who was in the act of painting with tar an incision in an apple-tree, " I suppose that the apples will taste of tar for a year or two, won't they?" When these ideas become a little more widely disseminated it is to be expected that progressive growers will be found pouring liberal doses of " Red-eye " into holes in their apple trees, by way of preparation for marketing their fruit in the prohibition States.

It cannot be too emphatically stated that no cement filling, nor any other filling, nor the removal of decay that precedes the filling, can have any physiologically beneficial effects upon the tree. Decay is harmful in exactly the same way that a hole cut in the tree with an ax is harmful. It interrupts, in proportion to its extent, the exchange of sap between the roots and the leaves, and it removes a certain part of the physical support of the tree. It is to prevent the increase of these very dangerous processes that the decay is cut out. But the excision does not, obviously, remedy the harm which has already been done. Indeed, it actually increases the damage to the tree, for the hole is always larger than the decay-spot it was made to eradicate. If better foliage sometimes follows the putting in of fillings, it is because the trees are often pruned severely at the time they are filled. No real advance in the work of repairing decaying trees can be made until this lumber of false notions is cleared away, and the real value of the work is studied and determined.

With this analysis of the purposes of tree filling in mind, let us pass now to a brief inventory of the different types of cavities, making an effort to estimate, in each case, the probability of a successful realization of these purposes.

The smaller holes in trees, caused by weathering and local or incipient decay starting from a decaying stub or a bark wound, can often be very rapidly and completely cleaned of rotten wood. The cavities can usually be well drained and not only are the fillings easily waterproofed, but they are likely to be callused over within a reasonable time. If properly done such fillings are almost sure to be wholly successful. They are of great importance in preventing the spread of decay and the formation of cavities more difficult to treat. No hesitancy should be felt in putting such work into trees of even secondary importance, or into orchard trees whose value is strictly commercial.

Next in the scale of simplicity are moderately developed basal cavities — rotting places, that is, at the base of the trunk. If in handling such cavities it is possible to remove all decay and to " ground " the filling, the work is sure to be effective and profitable. The rot which was gradually weakening the tree has been permanently eliminated.

A tree that is not worth filling

Danger from water pockets, the most frequent cause of failure in tree work, has been completely avoided by the good drainage produced by grounding the filling.

In basal cavities which have progressed farther, the decay working higher up the trunk, some of those advantages may be realized which follow the filling of simpler cavities of the same type, while others may not be. The main difficulty is in the removal of all the decay, especially when it runs higher up in the trunk and perhaps into several large limbs. In such a case the larger expense and the greater uncertainty as to effectiveness demand that careful consideration be given to the value of the damaged tree and to its possible future value, before the work is started.

When we come to large cavities in the upper part of the trunk, oftenest caused by the breaking out of large limbs, involving bad crotches and saddles, we come to the most difficult and most uncertain class of cavity work. The trees are often so old that their value is problematical at best. The great strain on the filling makes indispensable a great deal of expensive bolting through the trunk, with its unavoidable damage to the continuity of the cambium. It can be pretty definitely stated that fillings of this type cannot be done successfully with concrete. Such a filling has to be divided into small sections to accommodate the inevitable swaying and twisting. The divisions between the sections are certain, sooner or later, to admit water, and calluses will not grow over a filling which grinds against them in a wind. For such cavities as this, asphalt is now being advocated as a filling, but none of the different methods of using it has been tried out long enough to make its value absolutely certain. No large job of this kind should be undertaken unless the probability of large expense, and the possibility of ultimate failure are squarely recognized.

In this connection it may be noted that when the tree surgery companies publish photographs illustrating their largest jobs, the pictures are always observed to have been taken during the progress of the job or immediately upon its completion. When, however, they print pictures taken several years after the work is done (as in showing callus growth, which is supposed to be proof of success) the pictures are almost invariably of simple basal fillings.

By keeping in mind this scale, indicating roughly the relative costs and risks of the different classes of fillings, and also the preceding list of " don'ts " relative to expensive fillings in trees, it is possible for the owner of trees, or his adviser, to arrive at a pretty definite conclusion as to whether to order his decayed trees filled or not.

In view of what has already been said, it is hardly necessary to insist that it is impossible to answer with one word the question "Is filling trees successful?" It all depends on the tree, the cavity, and the filling. A small cavity in a healthy tree can be filled with certainty of success. A large and complex filling in a decrepit tree may well be beyond the power of any man to accomplish successfully at any cost. Somewhere between these limits lies the line of demarcation, fluctuating with the existing conditions and the skill of the workman. Further observations on old jobs may draw that line farther back toward the simple operations. Future inventions and greater skill may push the line out to a point where it will include more difficult work than has yet been attempted. The rules laid down in this chapter aim to locate the line as definitely as that can now be done.

In conclusion, for the sake of the emphasis which comes of repetition, let it be said again here, as it has already been said several times in various forms, that tree surgery is not nearly so important to trees as feeding, watering, and spraying, and that the common-sense, as well as the scientific procedure, is first to make the tree vigorous, and then, if it needs filling, to fill it.

CHAPTER VII

THE FILLING OF CAVITIES — MATERIALS AND TOOLS

THE treatment of cavities is the part of tree repair which presents the greatest technical difficulties, as well as the largest opportunities for the application of the principles of the nature and growth of trees and of the spread of decay. The causes of cavities in trees have already been stated. The many ways in which they are dangerous have also been touched on in several connections. Perhaps the clearest way to state the potential peril which lies in every cavity is to say that all cavities grow. Slowly, but steadily, every cavity grows larger and larger, until the exchange of sap between roots and leaves is so far cut off that the tree dies, or until the supporting framework of the tree is so far eaten away that the tree is broken down by the wind. Every cavity is therefore a stage in the steady course from the bark wound to the hollow, shattered tree. Other factors may bring about the death of the tree before the cavity gets in its work, but the cavity is always at least a potential cause of the tree's destruction.

It is no wonder, then, that heroic measures are often resorted to in order to stop the spread of a cavity. For, as the essential reason why they must be treated is that all cavities grow, so the essential principle of their treatment is to stop their growth. And, conversely, the degree to which a treatment is successful is the degree to which the growth of the cavity has been stopped. Although the essential idea in the treatment of cavities is to stop their growth, other principles are involved, which, though not primary, are by no means without importance. These are that the treatment must be such as to facilitate the healing over of the interruptions in the continuity of the bark which accompany wounds and cavities, and, in so far as possible, it should be such as to restore to the tree the strength which has been taken from it by the destruction of its tissues. The first of these is in one way a corollary to the principle first stated, that of stopping growth, because the healing over of a wound is the surest way to prevent reinfection.

The ways in which these principles are put into practice will appear later, but it may be well to lay down at this point a skeleton program of the different processes which are normally included in a complete cavity treatment:

1. The decaying wood is completely removed, the mouth of the cavity being enlarged as much as may be necessary to accomplish this.

2. The mouth of the cavity is so shaped as to insure a proper retention of the filling, and as to facilitate the healing of the wound.

3. Braces are put in to strengthen the tree, retain the filling, and prevent the opening of cracks around it.

4. The interior of the cleaned cavity is treated and dressed in such a way as to prevent the reinfection of the wood by fungi, and, in so far as is possible, to produce a water-tight connection between the filling and the wood.

5. The cavity is filled, care being taken that the surface of the filling is so arranged as not to interfere with the natural healing of the wound.

6. The surface of the filling is so treated as to make it water proof.

This outline may help to give unity to the rather piecemeal handling of the subject-matter of the chapter which is unavoidable from this point on. We shall first discuss the tools which are used in this branch of tree repair, then the materials, and, finally the methods.

TOOLS

The tools used in cavity work are those naturally suggested by the kind of work to be done.

In clearing away the dead wood, the main reliance is placed upon carpenters' gouges of the larger sizes, inch-and-a-half being perhaps the most useful size, while the two-inch size makes fast work if the wood is soft. Smaller sizes also have their special uses. It is hardly necessary to say that the gouges are outside-ground and socket-handled. This last feature is important on account of the frequency with which the handles break and have to be replaced. The best handles are made of sound ash or hickory, and are fairly large, with an iron ring around the butt. For work in large cavities long handles have to be fitted to the gouges. Old wagon spokes are the best stuff to use for this purpose. They can usually be got for nothing at any blacksmith's. The butts will have to be strengthened with an iron ring or the spokes will soon split. If these rings cannot be bought at the local hardware or department store substitutes can be made by sawing a gas-pipe into inch lengths.

Mallets, the invariable companions of the gouges, also come in several sizes and styles. Those of *lignum vitæ* usually last longest, but the wear and tear on them is very great, and a mallet which has a crack in it will not last long. Tastes differ as to weight of head and length of handle, but fast work cannot be done with a light mallet. The writer prefers the size known as number eleven (weighing a little less than two pounds), and a handle about ten inches long.

After these tools, perhaps the most useful is a light hand ax, especially in large work. An adz is also very useful, as is a pruning saw of the "meat-saw" type, the blade of which can be set at right angles to the handle, making it a handy tool when there is a large "lip" to be cut from the edge of a cavity.

Several more or less successful efforts have been made to devise machines for excavating decayed wood. As yet none of these has come into general use, the extremely variable conditions presented by work in trees giving human labor a peculiar advantage over the less easily controlled mechanical devices.

Under the head of tools ought also to be mentioned the ladders necessary for getting at the cavities to be excavated when they are high above ground. The devices used, the various combinations of ladders, step-ladders, planks, and ropes which are made for the purpose of securing a comfortable footing while at work, are endless. The work to be done and the materials at hand with which to do it will suggest to a handy man the best arrangements which can be made under the existing circumstances. It saves time to make the conditions of work in each case as comfortable as possible.

MATERIALS

Dressings.— It is natural, when the materials employed in the treatment of cavities are mentioned, to think first of concrete and the like. But of first importance are the dressings used on the interior of the cavity before the filling is put in. Logically, those materials are practically the same as the materials used for wound dressings, a subject considered at length in a previous chapter.

The materials of greatest value as dressings for cavities are creosote, the best preliminary disinfectant and preservative; coal tar, mainly of value when the cavity is dry and well-drained, and the various forms of fluxed asphalt.

Fillings.— A large number of different materials have been or are being used for filling trees. Concrete is of course the commonest of them. Lately, asphalt has been supplanting concrete for many kinds of work. In the present division of the chapter the principal materials and the ways in which they are prepared for use will be discussed, leaving for a later division an account of how they are put into the tree.

Concrete.— Cement is a fairly easy material to handle. Any one can mix up a pail of cement with a wheelbarrow or two of gravel, pour it into a soap box, and make a passable horse-block. But the ease with which a certain kind of success is attained with cement is apt to lead to ineffective results when the work is subjected to conditions at all trying. A person who wants to do good work with cement, work suited to the materials used and adapted to the end aimed at, must make himself familiar with the properties of cement and of concrete and with the principles governing the selection of materials entering into the concrete, the mixing of those materials, and the placing and hardening of the mixture. There is a number of cheap and excellent handbooks dealing with these matters, and one of them should be familiar to every user of cement. In this book, however, only the elements can be presented, and such details as bear directly on the use of concrete as a filling for trees.

It may be well to begin with a few definitions. Concrete is an artificial stone made up of small pieces of natural stone held together by a matrix produced by the crystallization of hydraulic cement and water. The materials held together, such as sand, gravel, or broken stone, are called the aggregates. Portland cement, the hydraulic cement commonly used for making concrete, contains lime, silica, alumina, and other elements, and is made by melting a limy substance with a clayey substance and grinding the resultant clinker to a very fine powder. It is this material alone which is correctly called cement, the mixture of it with water and any form of aggregate being concrete. The word cement is, however, frequently used to designate concrete, especially when the aggregates employed are small.

Concrete, then, is made by mixing cement with aggregates and with water. In order that the concrete may be good the materials of which it is made must be carefully selected. Portland cement is very uniform and it is safe to use the product of any of the large mills, or any brand sold by a reliable dealer. If kept for any length of time it must be protected from moisture, and must be dry and powdery when used. It comes in paper or cloth sacks containing about ninety-five pounds. Four sacks make a barrel and cost about a dollar and a half.

The aggregates present greater difficulties. In the first place, the type of aggregate best suited to the purpose must be determined. It has been the usual custom to employ simply a mixture of cement and sand for filling trees, on account of the fact that coarser aggregates make it difficult to work the exposed surface of the filling down smooth. A concrete made of small aggregates, however, is not so strong nor so dense as one in which larger aggregates are used. W. A. Radford, in "Cement and How to Use It," makes a clear statement of this principle:

"There is the closest relation between the density and the strength of concrete. Even a slight increase in weight per cubic foot will add very decidedly to the strength. In this connection the importance of the coarser aggregates cannot be too strongly insisted upon. The use of coarse material is essential to density, since coarse material contains the smallest amount of voids. Different kinds of sand, gravel, and stone vary greatly in the amount of their voids; and by judiciously mixing coarse and fine materials, the voids may be much reduced, and the weight and density of the concrete increased.

"If the sand be screened so as to take out the coarse grains, the voids will be increased and the weight reduced, thus injuring the sand for making concrete. Strength may be improved by adding coarse material, even though the proportion of cement is thereby reduced. This has been repeatedly shown by experiment. A mixture of cement and sand alone will form a rather weak concrete, especially if the sand is fine. By adding gravel — say about twice the quantity of gravel that there is of sand, or a little more — a concrete will be obtained containing, of course, a greatly reduced percentage of cement, but of greatly increased strength."

The strain on concrete fillings in trees is so great that a sacrifice of strength for a fancied esthetic effect is not easily justified. It is, moreover, not difficult to handle a rather coarse aggregate in such a way as to make a fairly smooth surface, especially if that surface is given a heavy waterproof dressing. Placing, as he does, efficiency before appearance, the writer urges the use of larger aggregates in making concrete for filling trees. Half-inch crushed stone makes an excellent material for the purpose, as also does screened gravel.

The selection and proportioning of the aggregates depend upon the principle that the most compact and strongest concrete is made by so grading the aggregates that the mixture may contain a minimum percentage of voids. Enough cement is mixed in to fill the voids, and the resultant concrete is practically solid. An ideal combination of aggregates, therefore, is one which brings together fine and coarse sand, small stones and large ones. A mixture of sand with screened gravel or broken stone conforms fairly closely to this ideal, as, to a slightly less degree, does bank gravel, a natural mixture of sand and gravel.

Good sand is fairly coarse, with grains of graduated sizes, and, above all, it must be clean. A coarse mixed sand requires less cement than a fine, uniform one. Besides the dead and dusty appearance of dirty sand when it is dry, the following test for fresh sand is very useful. The description of it is quoted from " Concrete Construction

About the Home and on the Farm," published by a cement company.

"Pick up a double handful of moist sand from the bank; open the hands, holding them with the thumbs up; rub the sand lightly between the hands, keeping them about half an inch apart, allowing the sand to slip quickly between them. Repeat this operation five or six times, then rub the hands lightly together so as to remove the fine grains of sand which adhere to them, and examine to see whether or not a thin film of sticky matter adheres to the fingers; if so, do not use the sand, for it contains loam."

Bank gravel makes a fairly good ready-mixed aggregate for concrete, although as a usual thing it is not correctly proportioned, the amount of sand being excessive. It is ordinarily best to put some of the gravel through a quarter-inch screen in order to determine what its actual composition is. Then, if a deficiency of the larger pebbles is indicated, enough screened gravel can be added to make the proportions correct. If pure sand has to be used it must be mixed at about the rate of two parts of sand to one of cement, in order to approximate the richness of a 1:4 gravel mixture.

The various mixtures of cement, aggregates, and water, which are used in making concrete are grouped in two ways: according to the proportion of cement to aggregates, and according to the amount of water incorporated in the mixture. A rich mix is one in which one part (by loose bulk) of cement is mixed with two parts of sand and three of gravel. A medium mixture runs about 1:3:6, and a lean mixture, 1:4:8. Arranged according to wetness, a very wet mixture is one which is mushy enough to run off the shovel, a medium mixture is jelly-like and will quake on tamping, while a dry mixture closely resembles damp earth.

For filling trees a rich mixture should ordinarily be employed, because the actual amount of cement used is small and because it is highly desirable that the filling set quickly and become very hard. In positions where there is but little strain on the filling, as beneath or near the surface of the soil, or in a large cavity with a small opening, a mixture of medium richness can be used with entire safety.

The degree of wetness is not so easily disposed of. For the most part a rather dry mixture has been used for filling trees. The difficulty of making a form into which to deposit the concrete almost compels the workman to use a mixture so dry that he can build it up without a form and without danger of its slumping down through the opening of the cavity. This is the easiest way to put in a concrete filling, and it has been almost the universal way. It is constantly being made clearer and clearer, however, that the dry system is subject to one very serious danger. Many fillings made in this way, though they may at first seem hard, gradually "rot." The writer believes that the explanation of this difficulty lies in the dryness of the mixture. There is a saying that a wet mixture tamps itself, but that a dry mixture must be tamped. A dry mixture which is not thoroughly tamped cannot make a dense concrete. Now it is almost impossible to tamp properly concrete which is being built up in a cavity. In the first place, there is not often much elbow-room and it is difficult to apply sufficient force. Then, too, a hearty ramming would almost surely cause the lower part of the filling to belly out or to fall out bodily. As a result, tree fillings are not often tamped with anywhere near the force considered essential in the manufacture of building blocks by the "dry method," which is practically the only large use of dry concrete. Such fillings are inevitably porous, and porous concrete is like a sponge. If there is any water about, the concrete will absorb it.

This brings us to another difficulty which often arises in connection with dry fillings. It often happens that a large part of what water there is in the mixture evaporates the very first day it is in place. Between this evaporation and the original scantiness of water, not enough is left to crystallize the cement in the concrete. When the con-

Cavity in the base of a white oak filled with concrete

crete dries out only a part of the cement really hardens. The rest, although its cementing value is destroyed, does not harden and is left in the concrete in an unfixed condition. Now when this concrete becomes saturated with water, and the water works downward and out of any drainage openings which may occur, it carries with it some of this loose cement, a condition of things which is betrayed by a light-colored stain on the bark below the opening of the cavity. As this process goes on the porousness of the concrete must obviously increase, and before long the filling is absolutely saturated, and has become rotten, friable, and weak. This result is the more surprising because a week after the filling is put in it usually seems as hard as flint, due to the fact that troweling and smoothing the surface draws to it a large amount of cement and water, which cause the surface of the filling to become really hard.

As a remedy for this state of affairs two solutions have been tried. The old method has been rid of some of its faults by making the mixture just as wet as it is possible to handle it, by paying greater attention to the tamping, and, especially, by preventing the access of water to the concrete by means of improved dressings for the inner surface of the cavity and the outer surface of the filling. At the same time, efforts have been made to find a practical means of handling a wet mixture, for therein lies the real solution of the problem. The writer has tried several schemes to overcome the mechanical difficulties presented by the wet mixture. The most successful of them, and also the best way of handling the dry mixture, will be described later under the general description of the method of filling cavities.

Little need be said concerning the details of mixing concrete and the like, for such matters are familiar to almost every one, and they are described fully in pamphlets which can be secured free of charge from the Government or the manufacturers, and in cheap and easily obtainable handbooks.

Something ought, however, to be said about quantities and costs. As soon as a job has progressed far enough to make possible an estimate of the cubical contents of the cavity, the amount of materials required to fill it should be figured out and provision made for obtaining them. To do this it is necessary to know how much cement and aggregates is needed to make a certain amount of concrete. Suppose the aggregate is a natural mixture of sand and gravel. It will be a little shy of gravel and the mixed sizes will not bulk as large as if they were separated, so you will have to use one part of cement to four parts of gravel to make the equivalent of a 1:2:4 concrete. At the rate of one to four, a bag of cement, three and three-quarters cubic feet of gravel, and five gallons of water will make a medium wet mixture which will make four and a quarter cubic feet of concrete. So by dividing the number of cubic feet in the cavity by 4¼ you can obtain the number of bags of cement to order, and by multiplying the number of bags of cement by 3¾, you can obtain the number of cubic feet of gravel required. If the sand and stone or gravel are secured separately, the amounts required can be calculated from the proportions of the ingredients of a cubic foot of concrete. A cubic foot of 1:2:4 concrete contains approximately .015 of a bag of cement, .016 cubic yard of sand, and .032 cubic yard of stone or gravel.

The cost of materials varies greatly in different parts of the country, but a fair average would be $1.50 a barrel for cement, $.80 a yard for sand, and $1.20 for stone. A combination of these figures with those above indicates that a cubic foot of 1:2:4 concrete contains $.056 worth of cement, $.013 of sand, and $.04 worth of stone, making the cubic foot cost, for materials, approximately eleven cents. It is more likely to exceed than not to reach that figure.

Asphalt.—It is now generally recognized that concrete is not fitted to serve as a filling material for every kind of cavity. With that recognition has come a demand for a more elastic material, more like wood in its properties, and capable of becoming more nearly like an integral part of the tree. The moment this need was stated, asphalt suggested itself as the material which most nearly meets the requirements. It is, indeed, practically the only solid filling material which has been brought forward as a substitute for concrete. Its eminent fitness is obvious. It is slightly elastic, while concrete is absolutely rigid; it is waterproof, while concrete absorbs water; it adheres to wood, while concrete does not; it is light and warm, while concrete is heavy and cold.

In a preceding chapter, under the topic of wound dressings, some of the various kinds of asphalt have been mentioned. It cannot as yet be definitely stated what form of asphalt is best suited to tree work. For outside waterproofing applications, the writer is convinced that bituminous cement made from the natural asphalt is the best. For cavity work it may sometimes be little more than a question of choosing the cheapest material, especially when the metal-front system is used.

Such brief description as is necessary of the methods of mixing the asphalt with other substances, in the preparation of the actual filling-material, is best deferred until the processes of filling appropriate to each material are being described.

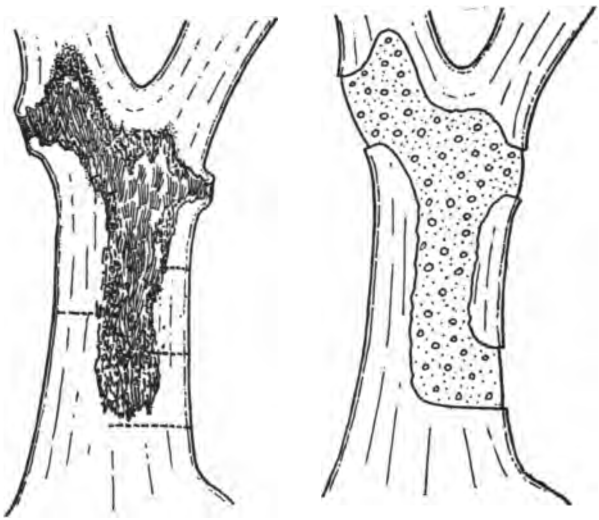
Chapter VIII

GENERAL METHOD OF FILLING CAVITIES

SO much for the materials used in dressing and filling cavities. Next in order is a general description of methods — the way the excavation is made, the way the hollow trunk is braced and filled. This general description will be followed by specific discussions of the various types of cavities and of the special problems each presents.

PRELIMINARY SURVEY

After it has been decided to fill a cavity in a certain tree, the first thing to be done is to make a careful investigation of the decayed portion of the trunk, the purpose being to map out the course to be followed in excavating the rotten wood. If openings already exist, as they usually do, it must be decided whether they will offer sufficient access to the decay, and, if not, how much they must be enlarged, or what new incisions must be made, and where. It is often wise to leave the cutting of new holes until after the excavation is well under way, but when the need of them can be clearly foreseen, it is an economy to cut them at once, so that each portion of decayed wood can be removed from the most convenient point. If the decay



Vertical section of a decayed oak, showing holes bored to determine extent of decay, and section of the same tree excavated and filled

runs down the trunk to the ground on any side, the soil must be dug away. It may be well to mention here that cavity work is very hard on the grass around the tree, and it is often well to lay down a piece of canvas or burlap, to protect the sod. Existing openings must in every case be enlarged to sound wood an inch or so thick, in order to provide a proper edge for the cavity. If there are old callus lips rolling over the side of the opening of the cavity, and there is rot behind them, they must be cut away. In case new incisions are necessary, they are made, when possible, at a place where there is already an injury to the tree, such as a patch of dead bark, or where the wood is thin and the slow growth of the bark indicates that the flow of sap will not be seriously interfered with by an incision. It requires considerable experience to enable a man to say in advance just how large an opening will be needed for removing the decayed wood from a cavity, but to do so often saves much time, for it frequently happens that a man chips a long time at a patch of dead wood which could have been very quickly removed through an opening made later on.

EXCAVATION

The openings once fixed on and made, the work of removing the rotten wood begins. At first this is usually easy enough, but it grows harder and harder as the work progresses. All sorts of tricks have to be used in order to get at all of the decay. Sometimes if a gouge won't "bite," a chisel, with its edge toward the wood, will do the work. An extension bit is also very useful in handling "pockets" of rotten wood.

"Punk-wood" can sometimes be burnt out with a gasoline torch, using a tree scraper to scrape off the charred wood and control the flame.

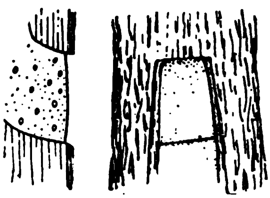
It would require a good many pages even to enumerate the hundreds of schemes and adaptations employed by a resourceful workman during a season's work. A person of normal ingenuity will not need any further suggestions along this line than are daily furnished by the work to be done and the tools at hand.

As the work nears completion, the operator must constantly keep in mind the standard of perfection decided on in the beginning. The tree has presumably been sounded (by boring holes, if necessary), and it has been definitely determined that all of the decay can and should be removed. We shall speak later of those cases in which it is found impossible to get out all the rotten wood. At present we are taking it for granted that complete excision has been prescribed. It may seem superfluous to say (but repeated experiences have shown that it is not) that "complete" does not mean "substantial." It does not mean that the rot is to be cleaned away perfectly where it is easy to get at, and yet permitted to remain in corners and crotches which are difficult of access. And too much must not be left for the antiseptic dressing, for few of the dressings soak in to any considerable depth. Half an inch is all that can usually be counted on.

Aside from the necessity of making sure that all infested wood is removed, it does not make much difference in what shape the interior of the cavity is left. It does not have to be smooth, except in so far as may be required by the nature of the dressing to be used. Tar, for instance, will not flow behind large semi-detached chips, but asphalt may cover them easily.

SHAPING THE MOUTH

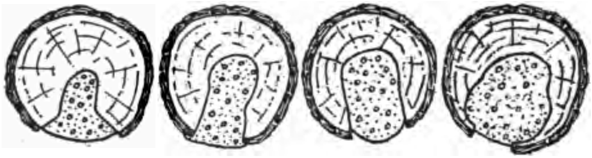
The excavation finished, the next step is the proper outlining and edging of the opening. The mouth of the cavity must be so shaped that the filling will be retained, the formation and growth of calluses facilitated, and the entrance of water into the cavity made unlikely. The first purpose is attained by making the cavity larger back of the mouth than it is just at the mouth. The entrance of water is made less easy by slanting upward the upper and lower edges of the opening, so as to form water-sheds.



Vertical section showing top and bottom of cavity slanted up to prevent entrance of water

If the top of the incision is made too square callus growth does not start from the top

As regards the encouragement of calluses, the important thing is to keep in mind the facts and rules concerning the cambium and the growth of calluses which have been explained in the chapter on the nature of tree growth. The mouth of the cavity should be kept as narrow as possible, the sides fairly straight and parallel to the strong-growing ridges of the trunk, and the ends of the



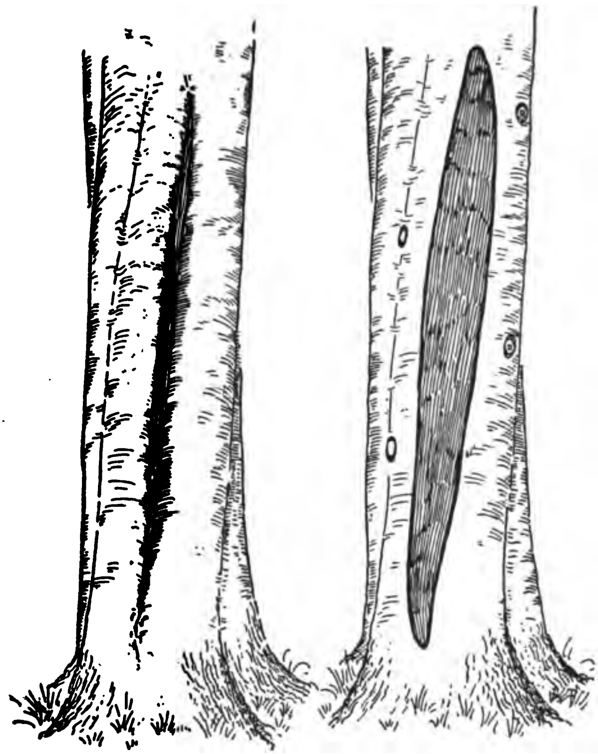
Cross sections of four incorrect fillings. In the first, the excavation is not correctly shaped for retaining the filling; in the second, the filling is brought out so far that the cambium cannot spread over it; in the third, the filling bulges too much; in the last, the wood at each side of the opening is cut too thin

opening should be tapered. Some otherwise skilful operators cut the top of the opening off square. That is a mistake, for if the tree is growing very slowly a triangular-shaped piece of bark just above the filling either dies or makes very slight growth, thus forming an ideal haven for boring insects. To avoid the possibility of the cambium's drying out, there must be a reasonable thickness of sap-wood beneath it, which means that very thin lips should be cut back to a point where the wood is an inch, say, in thickness. In this connection it may be noticed that there is always danger, especially when the bark is thin, that the cambium will be killed by drying back an inch or so from the edge of the opening. This amounts to an enlargement, by so much, of the wound, and measures should be taken to prevent it. If the job lasts several days, the temporary edge of the opening should be shellacked if the danger is considered sufficient to warrant the trouble. When the edges have finally been shaped and pared smooth, the bast and cambium and the wood an inch below it should be painted with shellac or liquid wax. Such treatment will not only prevent drying but also the killing of the cambium by the antiseptic dressing.

BRACING

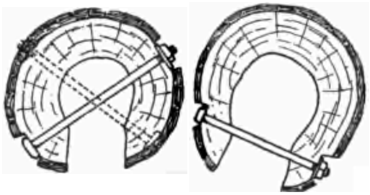
Bracing is next. Braces are put in to strengthen the tree, to make it more nearly rigid, in order that it may not crush the filling, to assist in the retention of the filling, and to prevent the opening up of cracks around its edges. For all these purposes it is almost futile to try to use braces which are entirely within the cavity. Such braces cannot be made stiff enough, and cannot be anchored strongly enough to the wood. The only way to do is to run the braces clean through from one side of the trunk to the other, which of course means that ordinary machine bolts are exactly suited to the purpose. The number of bolts depends upon the size of the tree, the thickness of the sound wood, and the number and size of the openings of the cavity. As the most common function of the braces is to prevent the formation of cracks around the filling, they are usually inserted as close to the mouth of the cavity as possible, reminding one of the stitches with which a surgeon closes up a wound. It is not often that the bolts need be closer together than eighteen inches. The diameter of the bolts should be kept down to the minimum of safety, not only to save on the cost of the iron, but also to avoid making unnecessarily large holes in the bark in inserting them. Considering that the steel of which machine bolts are made has a strength of fifty thousand pounds to the square inch, it is evident that anything larger than five-eighths bolts will not often be needed. Bolts in trees give way, when they do, by snapping off, or pulling out of, their heads. When ordering special sizes and extra lengths from the blacksmith the best way is to have both ends of the bolt threaded. A nut can be set on one end and can be considered as a head, or both nuts can be used to tighten up the bolt.

In case the slope of the bark toward the mouth of the cavity is such that a large socket would have to be cut in order to form level floors for the head of the bolt and the nut, it is better to run them

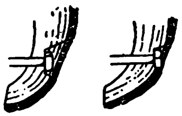


Beech tree with old trunk cavity and the same tree, excavated, braced, and filled with asphalt

through the center of the tree, only one end being near the edge of the cavity. The same method is advisable when the wood on either side of the cavity is very thin. After the location of the bolts is decided on, the holes for them should be bored, the sockets cut out or bored out with a large auger and measurements for the bolts made. These processes will be described at greater length in the chapter devoted to the bracing of limbs. Every effort should be made to keep the sockets as small as possible. Nor need they be cut much deeper than the cambium. Large, deep sockets,



Cross sections showing two ways of bracing a cavity



Sockets for bolts, one too deep, the other correct

in which the bolt head can be completely covered with cement, may look better to some people than smaller ones, but in them appearance is gained at the cost of lessened strength in the brace and greater damage to the tree. It is hardly necessary to say that the sockets and the bolts must be painted with some disinfectant, such as tar, before the bolt is inserted.

These bolts do not usually strengthen the tree to any great extent. There are a number of systems of bracing in common use which are claimed to strengthen the tree. In the writer's opinion they do not often materially do so. In one system a network of strap-iron, elaborately bolted together, is staggered back and forth inside the tree. But the reinforcing elements are so short and weak in comparison with the leverage of the limbs and the power of the wind, that it is difficult to believe that they have any substantial strengthening value. Another method is to reinforce the concrete with rods of steel, just as structural concrete is reinforced. This can only be of value when it is used in a long cavity which is decidedly more weakening in the middle than it is at either end. If the tree is weakest at the ground this system would increase the danger because it would destroy the shock-absorbing capacity of the trunk and make of it a lever by which the top could bear on the lowest part of the trunk. Doubtless these and similar systems of interior bracing have occasional uses, but before going to much expense in that direction it is a good idea to make a diagram of the proposed reinforcements and submit it to a civil or structural engineer. If his discussion of the project leaves you convinced of its value, go ahead.

In the case of a tree so far gone as to suggest such elaborate interior reinforcement, it will usually be best to employ the "open system" of cavity treatment which will be described in another chapter. Strengthen the weak limbs with outside braces. If possible, strengthen the whole tree by running wire ropes to it from its sturdier neighbors. These braces need not be conspicuous. Their strength is not problematical: it can be calculated to the pound. Plant a Virginia creeper or *Euonymus radicans* at the base of the old tree and spend the money you have saved in setting out a young one.

DRESSING THE CAVITY

The braces in place and tightened up, the next thing on the program is the antiseptic treatment of the interior of the cavity. The materials suitable for this purpose have already been enumerated. The choice of a material or a combination of materials depends upon the completeness with which it was possible to remove the decay, the condition of the exposed wood, and the shape of the cavity, and the material to be used in filling. If a penetrating antiseptic is needed, carbolineum is the most effective. If the wood exposed in excavating is damp it is essential that it be allowed to dry for a few days, the cambium, of course, being protected. It does no harm for a cavity to stand in this way half the summer. If time for natural drying is not available, the cavity can be dried out fairly well with a gasoline torch, though considerable discretion is needed in the use of that tool. A cavity which is to be filled with concrete should never receive, as its final dressing, any material less heavy than asphalt, unless it is a perfectly drained basal cavity, in which case coal tar can be used. Whatever material is chosen, it must be applied after the braces are in, and the application must be thorough and absolutely complete.

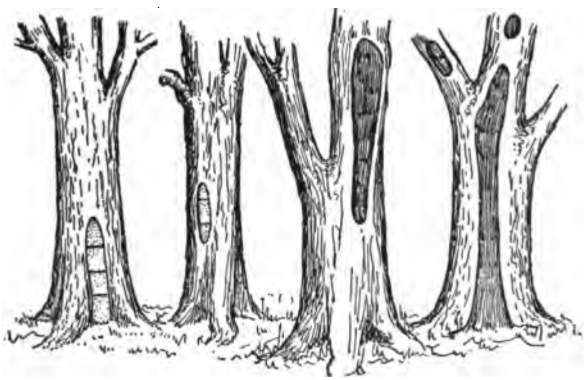
FUMIGATING

If boring insects have gained entrance through the trunk, and have progressed beyond the decay, so that some remain after the decay is removed, the cavity must be fumigated before it is filled. Tack a sheet of tar-paper over the mouth of the cavity, filling the interstices between the paper and the bark with clay or cotton-batting dipped in mud. Just before the last corner is packed down throw in a rag soaked with a teaspoonful of carbon bisulphide for each cubic foot of space in the cavity. If the cover is tight the larvæ will be dead in a few hours.

FILLING: CHOICE OF MATERIAL

The cavity is now ready for filling. The first question in that connection is the choice of a filling material. Concrete is still generally looked upon as probably the best filler for the more simple types of cavities, although its shortcomings and limitations are constantly being more widely recognized. Its advantages are that it is very cheap, is easily obtainable everywhere, requires none but common tools and appliances, and is easily and quickly put into the tree. On the other hand, it is absolutely unlike wood in all its properties, being heavy, cold and rigid, while wood is light, warm and elastic. It is very difficult to get a good junction between wood and cement. Cement is always somewhat porous, and usually damp, and attracts and condenses moisture, the greatest enemy of the life of wood. It is very weak when it is new, and is then and later frequently crushed by the immense strength of a bending and twisting tree. Almost the only thing in its favor is its convenience. Many situations and conditions, however, can be found in which the drawbacks of concrete are minimized in importance, and in which it is as good a material as any.

Perhaps an attempt to lay down certain rules covering these points would be worth while: In basal cavities which are well grounded and which do not extend up into the trunk a distance greater than two or three times its diameter, use concrete. In small cavities, at least so small in relation to the size of the trunk in which they occur that when the tree sways they move as a unit and do not vary much in shape, use concrete if the wood is dry. When the conditions are slightly more severe than these, concrete can often be used with safety, provided extreme care is taken with the braces, the dressing of the cavity, and the covering of the surface of the concrete. If the drainage is poor, if there are many openings, if the tree twists and bends in the wind, use asphalt. These rules govern fillings only. In a succeeding chapter will be found accounts of cavity treatments which do not



The two trees at the left are proper subjects for cement fillings. Those at the right must be filled with asphalt or treated by the open system, without fillings

involve filling, and also discussions of the value and proper use of each.

Coming now to the actual operations of putting in the filling, the methods of handling concrete will be described first — then the use of asphalt.

FILLING WITH CONCRETE

Concrete fillings can be put into trees in a number of different ways. And the differences, though at first glance they may seem of slight importance, are not so much differences of method as they are differences of purpose. In other words, the men who have developed the different systems, have had different ideas as to the function of cement fillings. In the early days of cement work in trees, it seems to have been taken for granted that the main value of the filling lay in its strengthening effect. The question of how this supposed effect was brought about does not seem to have been asked. It simply "seemed natural" that a tree which was full of hard cement should be stronger than a hollow tree. However, when irregular cracks appeared across the face of every large cement filling, and when the filled trees proved to be no more resistant to storms, apparently, than unfilled trees, tree-men began to ask themselves whether they were working on the right principle. The idea that the cement was of considerable strengthening value was not abandoned, however, and the difficulties which had developed were explained as being due to the absence of a sufficiently close bond between the concrete and the wood. The most obvious remedy for the trouble was to drive a lot of nails into the inner surface of the cavity. But the cracks still appeared. Continuing the same line of attack, an elaborate system of interior bracing or reinforcing was developed. This was an im-

Linden on Boston Common, excavated and bolted, ready for filling

provement on the simple cement filling, but its results were at best uncertain, and embarrassing fractures continued to appear in fillings of any considerable size.

About this time (1907) the writer had to take out a number of concrete fillings, some eight or ten years old, which, though otherwise well done, had been put in without previously treating in any way the inner surface of the excavated cavity. He observed, though hardly with surprise, that while the concrete was perfectly hard and sound, it was divided into sections, in every situation except the very base of a grounded filling, by roughly horizontal fractures. Many of these cracks were so small that they could hardly be detected on the surface of the concrete. These observations made it quite apparent that it is idle to try to increase the strength of a hollow trunk by filling it with a rigid back-bone of concrete. And a little consideration will make evident the soundness of this conclusion. The secret of the great strength of wood lies mainly in its elasticity, the ease with which it can be bent and twisted. Concrete is strong in quite a different way. It is almost perfectly rigid and inelastic. And it is futile to try to reinforce an elastic substance with an inelastic one. Suppose we have two beams, one of concrete and one of wood, bridging a certain space. Suppose the concrete beam has a breaking point of one thousand pounds, and that the wood will support the same weight, but that it bends three inches in doing so. If the beams are placed together and a weight of twelve hundred pounds is placed across them, what happens? The wood begins to bend, but it will hardly be supporting a hundred pounds before the concrete beam's limit of elasticity has been reached. The load on it being in excess of its strength, the concrete breaks, and the whole load falling on to the wood, it also gives way.

The importance of this difference in the character of the strength of the two materials is especially great just at the time the filling is put into the tree. It is well known that concrete, though it hardens with considerable rapidity, does not attain to its ultimate strength for a rather long period after it sets. It is this fact which explains the provision in all building codes to the effect that the forms must be left on structural concrete work at least two weeks. During the first day or two that the concrete is in place its tensile strength is very slight, even though the surface of it may seem quite hard. And it is absolutely inelastic. During this first day or two, however, the tree is certain to sway a little, and if there is much wind its trunk will be in motion from top to bottom. It is almost impossible to brace a tree so that it cannot bend, and it is quite impossible to brace it so that it cannot twist, and the raw concrete is just as weak under torsion as it is under tension. As an inevitable result minute fractures are produced in the filling, which forever destroy its tensile strength. It may be said that the concrete at least retains its compressive strength, and that it acts as a buttress to the tree. An architect might answer that a shallow buttress offers but little resistance to a horizontal stress, and a number of instances have come to the writer's notice in which the filling seemed to act as a fulcrum instead of a buttress, and actually helped to overturn the tree. Furthermore, trees are twisted off more often than they are blown straight over, and a concrete filling cannot offer much resistance to a twisting force.

All these considerations compel the conclusion that the idea that a concrete filling appreciably strengthens a tree is a mistaken one. What, then, is the true function of the filling? That function is threefold. The filling keeps insects, fungi, and water from gaining access to the heart of the tree; it forms a surface across which the calluses can grow, a growth which aids the tree physically and physiologically; and it probably has some value in preventing the collapse under strain of a hollow trunk, a value due entirely to its power of resisting compression.

The effect of this change in the purpose of filling is to make a fundamental difference in the technique of filling. It means that all effort to secure vertical rigidity can be abandoned. It means that a filling made up of horizontal layers will perform all the real functions of a filling, while at the same time it will control the formation of the inevitable cracks in the concrete. The "layer system" has been adopted by most tree repair men, although not always with a complete realization of the full significance of the principles which underlie it.

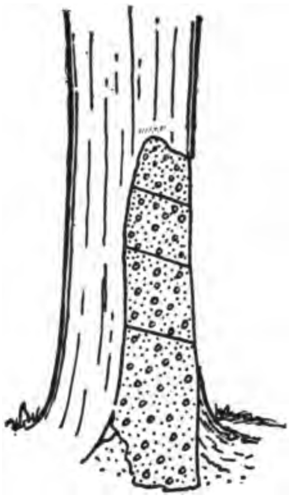
Justice demands that it be said, however, that in this branch of tree repair, as in most arts and sciences, there are two schools. Some arboriculturists still insist that the right way is to secure perfect rigidity throughout the concrete filling and perfect adhesion of the filling to the trunk. To the multitude of nails and numerous iron braces once generally in vogue, this school has added an intricate wire web, woven back and forth across the opening of the cavity, and fixed to the wood by a row of staples an inch or so inside of the cambium. Even though these efforts are successful in accomplishing their purpose, it is a matter of considerable doubt with the writer whether that purpose is worth accomplishing. Even granting that the filled portion of the trunk can be made perfectly rigid (and that is granting a great deal), it remains to be proved that a rigid trunk is more resistant to storms than an elastic trunk.

If we have, then, a simple cavity for which concrete is a suitable filling we know in advance that it will be useless to try to make of the filling a rigid mass. Our bracing has also been done with that principle in mind. Knowing the plan we are going to work on, we are ready to proceed with the work of filling the tree. There are, as has already been suggested, two ways of putting concrete into a cavity — the dry method and the wet method.

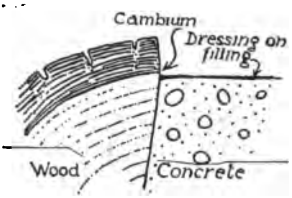
CONCRETE: DRY METHOD

The dry method is the commoner one. It looks simple but it is not an easy job for a beginner to set concrete up in an open cavity in such a way that it will be well tamped and compacted, and yet avoid "slumping" of the face of the filling. It is well to begin with a job which slopes back a little. It is not practicable, in this method, to use a very large aggregate. Mix a mortar of one part cement to four parts of natural gravel which has passed through a half-inch screen, making it so dry that a vertical wall can be cut in it without slumping, and yet so wet that a handful of it squeezed tightly will not fracture when the hand is opened.

Set a pail of this mortar and a pail of wet stones near the tree. After laying down a layer of stones in the back of the cavity and out to within four or five inches of its mouth, spread over them a layer of mortar. The best trowel for this purpose is a garden trowel to which has been fixed a rather heavy handle about fifteen inches long. Such a trowel scoops and carries better and spreads as well as the flat, diamond-shaped mason's trowel. The butt of the handle is handy as a tamp. After thoroughly compacting the cement about the stones, bring up the level of the front of the filling with mortar alone. Lay each trowelful down at right angles with the mouth of the cavity. Spread it back so as to bond with the stones, and pull it forward to the face, pressing it against a pointing trowel held in the left hand. Every layer must be carefully tamped and compacted by pounding and pressing it from above and pressing it inward from in front. If the filling extends up more than three feet above the surface of the soil (or less in a small tree) divide the filling into



Vertical section showing division of cement filling into sections horizontal sections. The interval between the joints (or "disjoints," rather) depends upon the amount of "give" in the trunk. Near the base of a tree a foot and a half is sufficiently short. Farther up, the sections should be smaller. One sometimes sees complicated fillings which are divided into sections of only four or five inches. The necessity for such ample provision for cracks usually indicates that the limitations of the usefulness of concrete have been exceeded. The divisions are produced by leveling off the top of the concrete as the filling is being built up, and spreading a sheet of paper over the level surface before continuing the filling. Newspaper does very well for this purpose, and has the advantage over heavier kinds that it offers no resistance to the trowel in cutting down the face of the filling. Thick tarred roofing paper has its advocates, however, their theory being that it gives the filling some elasticity under compression.



The concrete filling must be kept just below the cambium

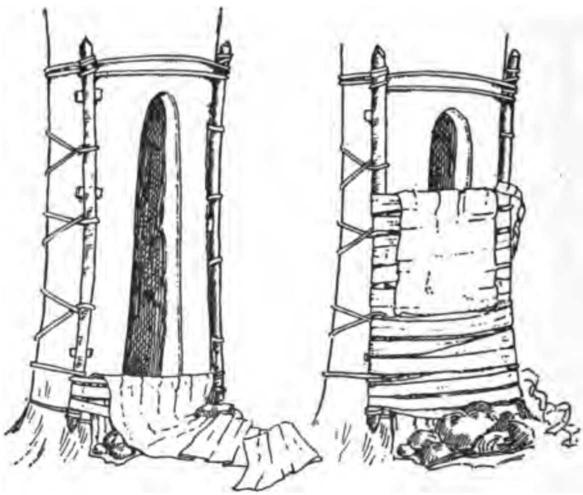
After the filling is completed, the next thing to attend to is its outer surface and conformation. At the edges the concrete should meet the wood just below the line of the cambium. The distance back of the cambium depends on the thickness of the dressing with which the surface of the concrete is to be protected. There is a natural tendency to rub the surface of the filling down smooth, but the subsequent surface dressing sticks better to the surface which results from cutting or paring down the cement with a trowel. The conformation of the filling should be graceful, following the curves of the trunk, but no effort should be made to imitate the bark or ridges of the natural tree. The curve from one side of the cavity to the other should not be full, but rather incline toward flatness.

CONCRETE: WET METHOD

The method, which will now be described, of filling cavities in trees with wet concrete mixture, depends on the closing of the opening with a dam of waterproof fabric (such as oil-cloth) held in place by strips of canvas across the opening, the dam being carried up the opening as fast as the mixture is deposited. The work is performed in the following way, a basal cavity of very moderate difficulty being taken as an example. Having completed the excavation and treated the interior, fill the lower part, up at least to the surface of the soil, with wet concrete. Then, if the tree is a large one, tie two poles to the trunk, one each side of the opening and six or eight inches from it.

They can be held in place at top and bottom by ropes running completely around the tree, and at intervals between by ropes around the back of the tree. Separate the poles from the tree by a number of inch blocks. Have ready a piece of oil-cloth or oiled canvas at least as wide as the widest part of the opening and as long as it is; also a large number of strips of canvas five or six inches wide.

Brush the shiny surface of the oil-cloth with light oil. Mix a batch of concrete, preferably near the tree, making it so wet that a man stepping on a pile of it will sink to his ankles. You are now ready to continue filling up the cavity. First hold the oil-cloth, shiny side in, against the opening of the cavity, the top edge of it reaching a few inches above the highest part of the opening and tack it there with a couple of brads. Fit the cloth, where it touches the ground, across the opening and hold it in place with a few shovelfuls of gravel. Tie a strip of canvas to the bottom of one of the poles and carry it across to the other pole in such a way as to hold the oil-cloth in place. Carry the canvas back and forth across the opening up to a point say eighteen inches above the surface of the soil. Loosen the oil-cloth from the brads holding it above, thus exposing the opening of the cavity. The lower part of the oil-cloth will of course be held against the opening by the canvas strips. Inspect the inside of the eighteen-inch wall or dam thus produced, making sure that it is firm and tight to the edges of the opening. If it appears possible that the mortar will escape along those edges, a rag or



Two stages in the process of filling a basal cavity with concrete by the wet method

some waste or a bit of clay can be used to plug up the loose places. Now shovel in the concrete, spreading and tamping it at the same time. See that it flows into every corner and that no part of it escapes the tamp. When the concrete has reached the top of the dam, give it a final tamping, level it off, and spread a sheet of newspaper over it, in order to make a division, as described earlier in the chapter. You are now ready to start a new section. Raise the end of the oil-cloth, tacking it up as before. Carry the strips of canvas back and forth across the opening until a height of a foot or so is reached. Then drop the oil-cloth, put in the concrete, and proceed as before.

When the filling is completed it must be allowed to stand for several hours, the exact time depending upon the weather, the richness and wetness of the mixture, and the size of the filling. If possible, put in the filling in the morning and inspect it occasionally during the afternoon. As soon as it becomes resistant to the fingers and a little force is required to cut into it with a trowel, take off the canvas strips and the oil-cloth. Then chip or scrape the filling off down to the proper level and contour, starting with the spots which require the most cutting away. If a pebble here and there runs farther back into the concrete than it is desired to cut, simply pull it out and leave a hole there. If the surface resulting from this process is not sufficiently smooth, dampen the surface thoroughly and cover it with a thin stucco of wet mortar made of one part cement and two parts sand. The stucco should be as shallow as possible; indeed, it is best simply to fill up the deeper holes made by knocking out stones from the filling. Shade the filling from the sun and after it has become a little harder sprinkle it with water occasionally to "cure" the surface. Finally, treat the surface with a waterproof compound or paint.

It is obvious that this method can be, indeed must be, modified to meet special needs and special conditions. If the filling is in a small tree the poles at the sides can be dispensed with, and the canvas strips can be run completely around the tree. If canvas is not handy, rope can be used, some slats and a piece of burlap, perhaps, or a piece of old carpet, being laid against the oil-cloth to stiffen it.

Some may think that a filling done in this way will result in too flat a surface across the mouth of the cavity. The writer considers a flattish surface stronger, more favorable to the growth of calluses, and better looking than a much rounded surface, but if greater convexity is desired it can easily be secured, either by leaving the canvas strips loose, so as to let the oil-cloth bag out a little, or by leaning a pole or two against the opening inside the oil-cloth, to hold it back from the opening. If the filling is so shallow that convexity is necessary to give it strength, asphalt ought to be used in place of concrete.

If for any reason it is desired to have the concrete harden very quickly, a ten per cent. solution of calcium chloride can be used in place of pure water. The mixture will harden three or four times as fast as it otherwise would. This percentage represents about eight pounds of chloride to ten gallons of water. The chloride costs about twelve cents a pound in small quantities; much less in larger ones.

Concrete fillings put in during frosty weather must be protected several days with blankets or straw. Some protection, also, is worth while when fillings are put into street trees. Small boys have a mania for scratching on fresh cement inscriptions which do not enhance its beauty.

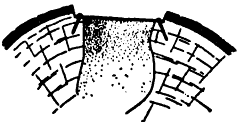
SURFACE-DRESSING ON CONCRETE

Concrete absorbs water, especially when it is only of moderate density, as concrete fillings are likely to be. To head off this absorption and the decay which usually follows it, every concrete filling should receive a waterproof dressing over its surface. For small fillings which are not much exposed to the weather and dampness, a couple of coats of tar will do very well, provided they are applied after the concrete has dried out. In all other cases it is best to give the concrete one or more coats of some special concrete paint. The writer uses Hoyt's cement paint, which has the virtue of sticking to a slightly damp surface. When the paint has dried a coat of tar can be put on as an additional protection and because black is probably the best color for fillings. Many workmen apply slaters' cement to the wood just inside the mouth of the cavity, with the idea of filling in advance the crack which always forms between the concrete and the wood. I have not found that method very successful, but I often apply the slaters' cement rather thickly to the region of the crack after the filling has dried out.

FILLING WITH ASPHALT

There are many ways in which asphalt can be used for filling trees. Invariably, however, it is mixed with a cheaper material, being used as a cement rather than as a homogeneous filling. The materials thus cemented together may be sand, sawdust, or excelsior.

Mixed with sand, as it is in paving, it cannot readily be built up and surfaced, so that if sand is used as an aggregate the cavity must be given a front wall of sheet metal to act as a dam while the mixture is being put in and as a protection to the surface after the job is done. If this method is used a shallow ledge must be cut along each side of the cavity, as for ordinary tinning. A sheet of zinc is then cut to



Section of cavity filled with a metal-front asphalt filling fit from side to side of the cavity and is nailed to the ledges. In the cavity, back of the zinc, is now packed the hot sand-asphalt mixture. The mixture is made by stirring about six parts of hot sand (rather fine, and preferably of various sizes, down to dust) into the melted asphalt. The mixture resembles a heavy bran mash and can be handled with a shovel or trowel. It must be thoroughly tamped. When the filling has been brought up to the level of the first length of zinc another sheet is cut and nailed in place, overlapping the first slightly, like shingles. Finally, the metal is tapped over with a hammer to smooth it out and is given a thorough waterproof dressing.

This method is of considerable value for filling cavities whose sides are so shaped that the metal can easily be fitted to the sides, and whose sides, either naturally or as a result of bracing, are rigid, the mouth of the cavity not opening and closing slightly in storms, as it is so wont to do. If the latter is the case the metal will be torn from the nails which fix it to the wood. In many instances the metal will be sufficient without the use of an expensive backing of asphalt. In other cases a cheaper backing will be found quite as satisfactory. The value of the metal-front asphalt-sand filling is therefore limited, because it cannot meet severe demands and because moderate demands are as well met by cheaper systems of cavity treatment.

Better fitted to do the things which concrete has failed to do, and adapted to the treatment of every sort of cavity, is the "asphalt briquette system."[1] The central idea of the method is the use of briquettes, of various sizes, made of excelsior, or excelsior and sawdust, bound together with asphalt. A wall is built up, in the front part of the cavity, of briquettes cemented together with melted asphalt. To prevent the possibility of a crack opening between the filling and the wood, as invariably occurs with concrete, the briquettes next to the wood are nailed to it. The wall of briquettes is reinforced by braces from the back of the cavity. The remainder of the cavity, back of the front wall, is filled with any one of a number of materials, such as "asphalt staff" (excelsior cemented together with asphalt), sawdust, or cinders.

Besides the briquettes, there must be on hand before work begins a supply of asphalt cement and of fluxing oil, such as "Varnolene," a kettle in which to melt the asphalt, another kettle, possibly smaller, in which to mix asphalt and sawdust, provisions for heating the kettles and for protecting the grass while doing so, a supply of sawdust and excelsior, some odds and ends of boards, ten-

[1] An application has been filed for a patent covering this method, and those who wish to use it should apply to Mr. C. H. Hoyt, Citizens Building, Cleveland, who can also supply the asphalt briquettes.

penny nails, some fairly heavy wire, and the necessary tools, such as hammer, gouge, mallet, and pliers.

The preparation of the cavity for an asphalt briquette filling is not essentially unlike the preparation for a filling of concrete. The decay must all come out, of course, in either case.

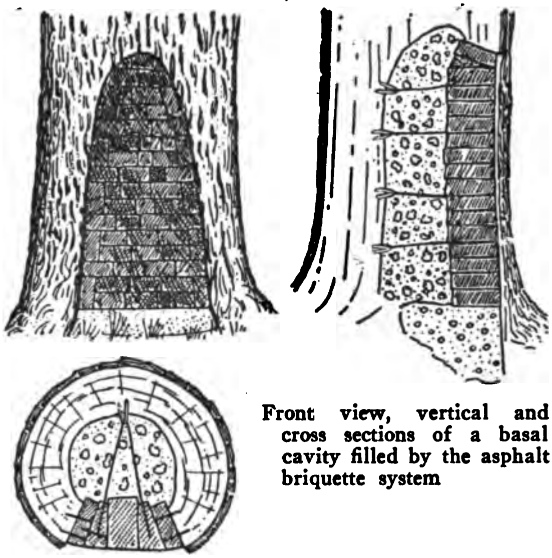
For concrete the cavity must be wedge-shaped, smaller in front than in back. For asphalt it is desirable that the sides of the cavity be as near perpendicular as possible to the face of the future filling. There is no change in the rules as to the handling of the cambium and the shaping of the incision in order to facilitate the growth of the callus over the filling.

The interior must receive a dressing just as for concrete. A hot mixture of asphalt and a small amount of fluxing oil is the best for the purpose, because it stays sticky for some time.

Previous, however, to the application of this dressing, such braces must be put in as are necessary, and a method of reinforcing or bracing the briquette wall must be decided on and provided for. The different ways in which the wall can be strengthened will be taken up later on.

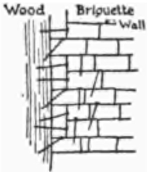
If the cavity is a basal one and extends below the ground, the lower part up to the surface of the soil, or two or three inches above it, must be filled with concrete, or partly with cinders or the like. When the concrete is hard the work of filling with asphalt begins.

Paint the upper surface of the concrete, which has been leveled off, with asphalt. Have a kettle



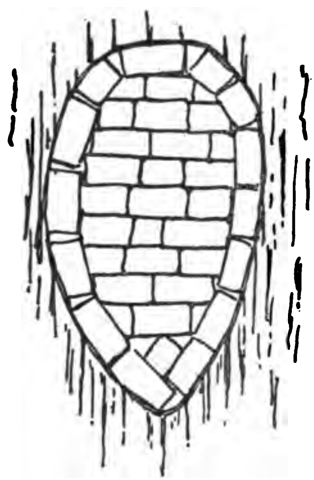
Front view, vertical and cross sections of a basal cavity filled by the asphalt briquette system

of melted asphalt near the cavity. Drive a nail nearly through one of the briquettes near its end. Spear the briquette with an awl and dip it into the hot asphalt. Lay it along side the wood with its outer edge about a quarter of an inch back from the cambium. Drive in the nail and pull out the awl. If a wedge-shaped space remains between the back part of the briquette and the wood, it had better be filled up with a mixture of about equal parts of asphalt and sawdust. Set a similar briquette against the wood on the other side of the cavity. Now you can fill in between the two briquettes in place. Take a briquette on the awl, dip it, and place it on its longer side on the concrete, its front being flush with the first briquette and with the edge of the concrete. Lay another briquette beside the first and continue the course over to the other side of the cavity. Lay on two more courses in the same way. This will bring the flat courses up to a level with the top of the briquette nailed to the wood at the sides of the cavity. Start the next course by laying a briquette with its narrow edge against the wood. Nail this briquette to the wood and to the briquette below it. Finish the course. Then, at each side, nail a briquette flat against the wood. Build the wall up between them, lay another course from wood to wood, and so on.



Section showing method of bonding wall and wood

This process is more complicated, naturally, when the side of the cavity is slanting or curved. The principal difference is that the soft asphalt-sawdust mixture is more often called on to fill crevices and corners. The necessary care required for fixing the briquettes at the edges of the wall to the wood depends upon the degree of probability there is that a crack will open up between the filling and the wood. If the briquettes at the side are tightly nailed to the wood, when the tree sways the enlargement of the mouth of



Arrangement of briquettes in an oval cavity

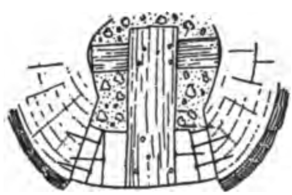
the cavity will be taken up by the elasticity of the briquette wall. If none of the briquettes is nailed to the wood, a crack may appear, under certain circumstances, along the edge of the filling.

In carrying up the wall it is well to keep its face as smooth as possible, particularly at the sides, but it is not difficult to smooth the surface with a hammer, or to cut off projections with a chisel, after the wall is finished.

At intervals, as it is built up, the wall will need bracing. The amount of bracing required depends principally upon the width of the wall. If it is not more than a foot wide, no bracing will ordinarily be needed. There are two types of braces, those which prevent the wall from bulging out and those which prevent it from caving in. The first function is best performed by wire, the second by pieces of wood.

There are two good ways of handling the wire. The most obvious plan is to drive some staples into the back of the cavity and run short lengths of wire from them to the wall. The easiest way is to employ V's of wire having the ends bent down at right angles. One limb of the V-shaped wire is threaded through the staple and the bent ends are driven into the briquettes. One of these V's is put into every second or third course. Another way is to use the same kind of V's, but to anchor them, not to staples, but to a strong wire run from one end of the cavity to the other from bolts or pieces of wood across its top and bottom. The advantage of this last plan is that greater elasticity is permitted to the wall without loss of strength.

The wooden braces also take several forms. For example a board can be laid on the surface of the back filling, fitting in snugly between the briquette wall and the rear wall of the cavity. Or a little longer board can be built right into the briquette wall, being nailed to the briquettes and extending back far enough to touch the back of the cavity. Such a brace can be made to resist a pulling as well as a pushing force by nailing to it a cross-piece fitted into a part of the cavity which is wider than the mouth.



Wooden brace for asphalt-briquette wall

It must not be supposed, however, that the asphalt wall is of itself weak. On the contrary, it is very strong, but the conditions surrounding work in trees are so extremely trying that braces which may never be called on to undergo an ounce of strain ought to be put in, if only by way of insurance.

The filling in the space back of the wall forms a backing for the wall, helping to hold it in place. The filling also helps in putting in some types of braces and it holds them in place. On the whole, I am inclined to consider coal ashes or fine cinders the best material for filling the space back of the briquette wall, on account of their packing qualities, their cheapness, and the fact that they need no treatment to make them proof against insects and decay.

Cavity in large red maple. The lower part was filled with concrete and the upper part was tinned

This back-filling should be carried up along with the briquette wall, and it should be thoroughly pressed or tamped into place in order to prevent subsequent settling. If it is felt that these materials would not give a sufficiently staple backing for the wall, the entire filling can be made of briquettes, of hot asphalt-sawdust mixture, of "asphalt-staff," or of ordinary staff made of excelsior and plaster of Paris.

In large cavities it is well to provide for the ventilation of the filling. The best way to do this is to leave out a briquette near the bottom of the wall and another near the top. The holes thus formed must be provided with a netting to keep the filling in and insects out. The face of the wall for an inch or two around the opening can be painted with hot asphalt and a piece of copper or brass netting can be pressed against the opening and held there until the hardening asphalt cements it in place.

The surface of a filling made in accordance with these specifications for the asphalt-wood briquette system is likely to be rather irregular, but it is not likely to be irregular enough to interfere with the growth of the calluses; yet it may be desirable, from the esthetic standpoint, to make it smoother. It is not difficult, with a broad, sharp chisel or gouge, frequently dipped in oil, to cut away the corners of projecting briquettes.

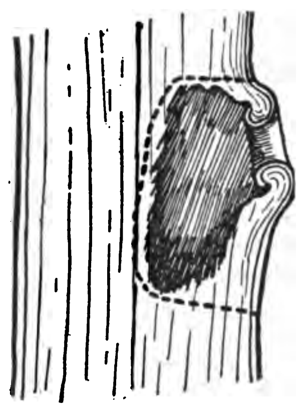
Then the surface can be warmed with a gasoline torch, not held too near, and irregular places can be pounded down with a mallet. Finally, the entire surface must be given a heavy coat of hot asphalt to which about one fifth of its bulk of "Varnolene" oil has been added. In some cases it may be worth while to reinforce this dressing with cotton padding in the way that has been described in discussing the treatment of wounds.

Besides being used in the form of briquettes, a mixture of asphalt with excelsior or with sawdust, at the rate of about a pound of sawdust to three pounds of asphalt, has great value applied directly to the cavity, especially for filling small holes. All that is necessary is to melt the asphalt, mix in the excelsior or sawdust and press the mixture into the cavity. A little practical experience will teach any one the points which must be observed in handling these materials. The "asphalt staff," for instance, must be held in place a few minutes until it hardens. After a filling of staff has hardened it can be trimmed to shape, and can be nailed to the wood by nails driven slantwise through its edges. Finally, it must receive a thorough dressing of metal or fluxed asphalt. Many combinations of briquettes with staff or asphalt-sawdust mixture will at once suggest themselves.

CHAPTER IX

THE VARIOUS TYPES OF CAVITIES

THIS general description of the procedure to be followed in the filling of cavities with the various materials employed for that purpose must in practice constantly be modified to suit special conditions. In the following pages the commoner types of cavities will be taken up and the principal measures and materials best suited to the handling of each will be described.



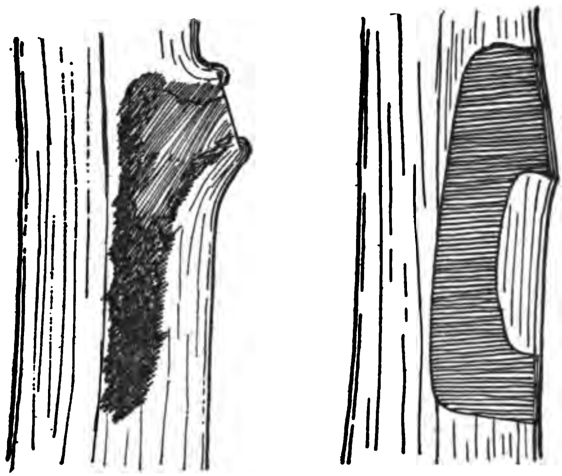
Section of rotten stub, with dotted line indicating correct excavation

Rotten knot-holes and decayed stubs constitute the commonest type of cavity. Many large and serious cavities have their origin in the stubs resulting from the death of limbs or the incorrect removal or treatment of limbs by pruners. Holes of this kind are extremely common, and it is often necessary that the treatment given them be rapid and economical. If such a cavity is shallow the best way to handle it is to employ the open system, to be described in the next chapter, in which no filling is used.

Deeper holes, in which the open treatment would involve too large an incision and the cutting away of too much bark, must be filled. Although in some cases complete removal of the decayed wood is neither possible nor desirable (and of those cases we shall have more to say in a later chapter), for the most part the general principles of cavity work apply as well to small holes as to large ones.

The first step, then, is the removal of the decayed wood. To do this thoroughly often involves considerable difficulty. The mouth of the hole must usually be enlarged, especially downward, and it may be necessary, if the decay runs far down the trunk, to cut in from below to get at it. More than one such opening may be required. In that case, a considerable distance should be left between the openings, for otherwise the intervening patch of bark will die. These holes must be cut only when it is absolutely necessary, for every such opening increases the risk of the entrance of water and of other troubles with the filling. The excavation finished, the mouth of the hole should be trimmed up and cleared of ingrowing callus.

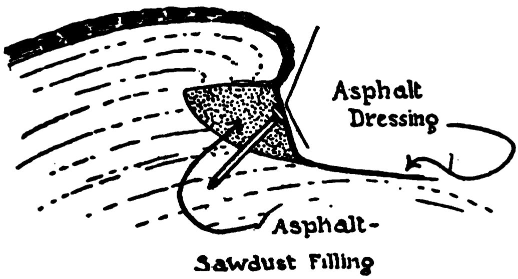
The filling material to use in such a cavity depends upon its shape and upon its position in the



Deeply decayed knot-hole and the same excavated and filled with asphalt

tree. If it is in a large trunk where there is likely to be but little strain on the filling, cement will do very well, after, of course, a thorough dressing with some form of asphaltum. If, however, the hole is in a limb, and at a point where there is considerable twist and bend, cement will not do, for it will break up and perhaps be forced out of place. In that case the filling must be elastic. Use asphalt briquettes and a mixture of hot asphalt and sawdust, or the mixture alone. In every case a dressing of asphalt must complete the filling.

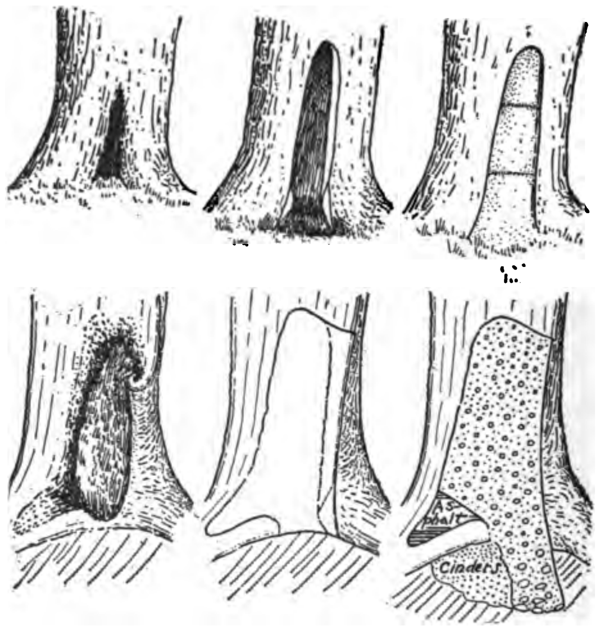
For the odds and ends of small holes, in so far as they need filling, a mixture of asphalt and saw-



Shallow cavity under a callus filled with asphalt-sawdust mixture

dust, or excelsior, or both, is the safest material to use. For instance: It is often found that the surface of a large old bark wound is decayed three or four inches deep. In cleaning away the decay the healthy calluses at the sides of the wound may be undermined several inches. The asphalt-sawdust mixture is just the thing with which to fill in under the overhanging callus. A few nails can be driven through it as it is cooling.

The commonest and simplest form of large cavity is the basal cavity. Basal cavities are caused by decay which enters the trunk at or near the ground, through a wound in the bark, or through a dead root. The only difficulties likely to be met with in handling such a cavity are the thorough excavation of the decay in the roots, if it has worked deeply into them, and the correct handling of the filling in relation to the lower parts of the incision, where complications may be produced by the growth or death of roots. As regards the excavation, every effort must be made to make it complete. If necessary, the opening of the cavity can be enlarged and carried up the trunk, or a new opening can be made, preferably in one of the depressions between the main roots. If the fungus causing the decay is one which destroys the heartwood only, it will not be necessary, in case it has worked down into the large roots, to follow it far. The decay is likely to cause less damage in the root than would an incision large enough to make possible its complete removal. But as far as the excavation is carried it must be thorough, so that there may be no connection between the remaining decay and the heartwood of the trunk. In making incisions in and about the roots, care must be taken that the free flow of sap is not sacrificed to neatness of outline and ease of filling. In order to " ground " the filling correctly it is usually necessary to dig down a foot or so just in front of the opening of the cavity. The soil should be dug away from the roots wherever there is any decay or possibil-



Views and sections illustrating the excavation and filling of a simple basal cavity

ity of decay, and the grounding and drainage of the filling should be carefully provided for. If the decay has worked down to the ground under the trunk, as it often does in trees which have not large tap-roots, the humus and soil must be dug away several inches so as to give a chance to inspect and treat the remaining roots.

All decay having been removed, but little more cutting is usually required. No great effort should be made below the surface of the soil, as is often necessary in handling openings in the upper trunk to arrange the edges of the cavity in such a way that the calluses will heal over the filling. It is possible to do much in that way only at the foot of the filling, in connecting up the filling with the large roots usually found on each side of a basal cavity. The patches of bark which have to be removed from the roots in this operation are of slight consequence, on account of the fact that they are aside from the main flow of sap.

Basal cavities of the type we have been discussing do not often need any bracing. The center is so much larger than the mouth that bracing is not frequently required to retain the filling in place, and it is not possible to add much strength to a tree by putting in braces so low down in the trunk.

As a dressing for the inside of the cavity, tar will do very well, for the good drainage removes the principal reason for a heavier covering of the wood.

The work of filling the excavation is fairly simple. If there are any pockets, such as might be caused by removing the decay from a root, they must be filled up with asphalt or a heavy mixture of ashes and tar. The next step depends upon the nature of the bottom of the excavation, especially as regards the number of exposed roots. If the soil has been dug out from beneath the crown of the roots, it is usually better to replace it with packed ashes or gravel before beginning the concrete filling. The reason for this is that these materials do not pinch growing roots, as concrete does, and yet they are effective guards against insects. In front, however, the concrete ought to be carried fairly deep into the ground, especially if there is any idea that the filling will serve as a strengthening buttress to the tree.

The concrete filling should next be put in. Though it may seem that the tree can sway but little so near the ground, it is usually advisable to divide even a low basal filling into sections, in order to anticipate and control the formation of cracks. The first division may be two feet, more or less, from the ground, according as the tree is large or small.

Concrete fillings of basal cavities can often be left without any surface dressing. As a rule, however, it is safer to paint them, after they have hardened, with tar or asphalt, giving particular attention to the edges.

In cases where the decay, starting at the base of a tree, has worked upward in the trunk, the proper treatment is identical with that just described for simple basal cavities, with the exception that braces may be required in order to prevent the opening of cracks at the sides of the filling.

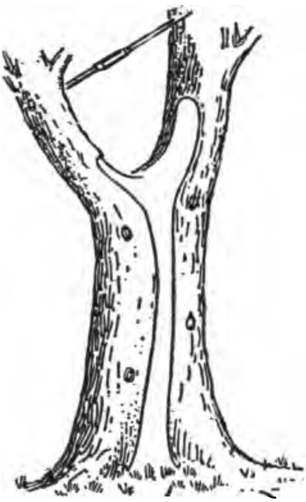
Much more difficult to handle than basal cavities are those in the upper part of the trunk, caused, for the most part, by the wrenching out of a large limb or by some severe injury to the bark. The difficulty of the excavation depends upon the age of the injury. If the decay has worked far up or down the trunk it may be necessary greatly to enlarge the original opening. The direction and size of the enlargement should be investigated in advance by sounding the tree, if necessary, with a half-inch bit. Once the exact extent of the decay is known, it is easy to determine the size of the opening necessary for the complete removal of the decay. If the shell of the tree is thin it is best simply to enlarge the existing opening, but if a considerable thickness of sound wood remains, it is well to try to get at the decay from separate openings, above or below the original one, but not less than a foot from it. Or the new opening may be made on another side of the tree if a good opportunity presents itself — a bark wound, for instance, a rotten stub, or a very slow-going area — to make an incision without doing much damage to the tree. The reason for the difference is that the wood between the main opening and the auxiliary ones is left for its strengthening value, and if the shell is thin no such value is present. Then, too, a thin patch of wood between two holes, one of which is above the other, is likely to die, dry out, check, and admit new decay. Once the size and place of the openings are decided on, they should be made, for to delay each inch of enlargement of a cavity until it becomes absolutely necessary to make possible the use of the gouge, means that the work is constantly being done at a disadvantage. It is all hard where part of it might be easy.

The great point about handling the excavation of this type of cavity is to make sure, if concrete is used as a filling material, that good drainage is provided. This means that there must be a downward slope from the lowest part of the cavity, inside, to the lowest part of the opening. If such is the case, any water which may enter the cavity before the crack between the concrete and the wood is covered by the growth of callus, will be drained out at the bottom. To be sure, it is not very reassuring to have to provide for such a possibility, but experience has shown that it is wise to provide for the disposal of water in cavities, when filled with concrete, even though the correct dressing of the cavity and of the outer surface of the filling may reduce the possibility of the entrance of water or of damage resulting from it if it should enter, to a minimum. When too great an excision of sound wood is required to secure drainage, the lower part of the cavity, up to the level of the opening, can be filled with asphalt, the balance of the cavity being concreted.

Careful bracing is ordinarily very essential to the successful treatment of a large trunk cavity. The amount of iron to be used, and its distribution, of course depend upon the strength of the remaining sound wood and upon the strain it is subjected to. Cavities having an opening of any considerable vertical dimension generally need horizontal braces. If the excavation has left the trunk very weak the tree as a whole should be braced to a stake or to a neighboring tree, as will be described in the chapter on bracing. The possibility of reducing the strain on the trunk by pruning in some of the branches should also be considered.

The dressing of the interior of a trunk cavity should be as thoroughly done as it possibly can be, and the most effective materials should be used. If the inner surface is easy to get at, melted asphalt is the ideal dressing; if difficult, a dissolved asphalt is likely to be more satisfactory. The braces must be coated, of course, along with the wood.

With the choice of a material for filling, we come to the most serious problem presented by this type of cavity. General rules for the choice of filling materials have already been laid down, and there is little that need here be added to them. Asphalt is distinctly the best material, but if the opening is reasonably small, the cavity well drained, and the probable strain on the filling not great, a concrete filling, well put in, may be fairly satisfactory.



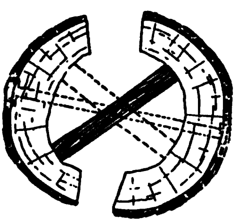
Typical saddle-cavity showing distribution of braces

The surface of the concrete, if used, must be given a waterproof application, after it has thoroughly hardened.

When injuries to the trunk occur near crotches, very bad cavities often develop. They are due, usually, to the death of a large limb or the death or breaking off of the upper part of the trunk. The resultant cavity is called a "saddle." It is hard to make a good job out of a saddle filling, for the reason that parts of the filling are likely to be horizontal or nearly so, making waterproofing difficult, while the large amount of sway and movement in the branches up which the saddle extends makes it doubly difficult to keep the filling water-tight. The wood on the upper side of limbs, also, grows much more slowly than that on the under side, and calluses are formed with equal slowness. Saddles, therefore, are likely to be healed over very slowly, so that though good work is especially difficult, it is also especially necessary.

The solution lies in correct bracing, correct filling, and correct dressing of the surface of the filling.

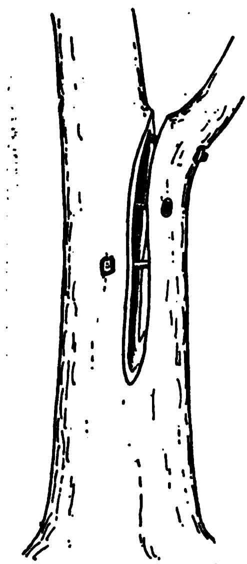
In bracing the first thing to be done is to put in a brace up above from one limb to another or from the trunk to the weak limb, in such a way as to take most of the strain off the base of the limb. Then bolts must be run through the saddle or just below it, in order to minimize the amount the mouth of the cavity will open and shut during a high wind. It may be that some short pieces of gas-pipe or of hard wood can be fixed in the cavity, pried in in such a way as to make the walls as nearly rigid as possible.



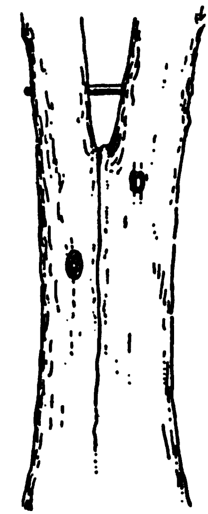
Braces in hollow split tree

Cement should never be used in filling a saddle cavity. If the tree is not worth a filling of asphalt the cavity should be left unfilled.

A split crotch is another hard proposition. If decay has entered it may be necessary to enlarge the crack between the limbs or to make other in-



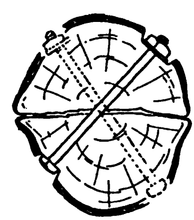
Crotch cavity braced, ready for filling



Bracing of a split crotch

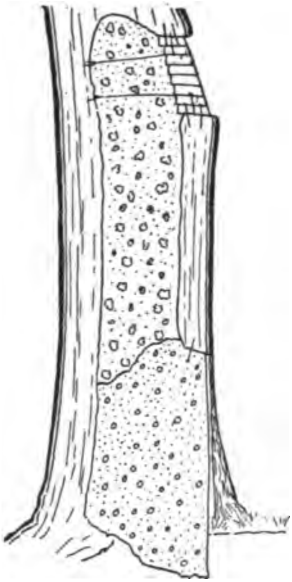
cisions in order to get at the rotten wood. In such a case the treatment should be guided by what has been said about saddle cavities. If, however, decay has not entered, the crotch should be cleaned, as far as it easily can be, of loose bark and other débris. If damp it should be left a while to dry. Spray it with creosote, then build up a dam of moist clay, covering the crack nearly to the top. The clay can be held in place by boards, which are themselves held by ropes around the tree. Fill the split by pouring in hot asphalt through the opening at the top. An asphalt of a rather low melting point, or one slightly fluxed with oil, is preferable to a very hard one. The asphalt must ordinarily be used clear, but if the crack is a large one it may do to mix some sawdust with it.

The braces through the split limbs and also, preferably, up above, must be set in place before the asphalt is poured, and then tightened up after it has hardened. It is in many cases well to put in a pair of bolts through the trunk at an angle with the plane of fracture.



Split tree bolted together

The last form of cavity we shall consider is the "chimney cavity," which results from the complete decay of the heartwood of a tree. It is almost invariably marked by a basal opening at the ground and another large opening at the top, where a large limb or the top of the main trunk itself, has been broken off. The hard proposition connected with this type of cavity is the excavation of the decayed wood. If the decay is difficult to get out and the line of separation between the sound wood and the decayed wood is not well marked, and especially if the decay has worked up into a number of branches, it is usually not worth while to try to excavate and fill the tree. It is better by far to brace the tree, if it needs it, fumigate the cavity, spray it perhaps with carbolineum, make all openings in the tree water-tight, and use the money saved by not filling it in bettering the soil or planting a new tree. In other cases, especially when the decay has proceeded farther, it may be comparatively easy to get most of the rotten wood with the help of a hoe and long-handled gouges. Sometimes the decayed punk can be expeditiously got rid of by saturating a part of it at a time with coal oil and burning it out, care being taken to control the draft.



Vertical section of a hollow tree, showing the basal opening plugged with concrete and the upper opening with asphalt briquettes. The intervening space is filled with cinders

The decay substantially cleared away, the cavity should be dried by leaving it a few days or by building a fire at the bottom of it. Then the inner walls must be sprayed thoroughly with carbolineum, a little loose soil being thrown into the bottom of the cavity to catch the drip, which might injure the roots. If the cavity walls are fairly smooth and easily accessible they may now be painted with asphalt in some form.

The filling should be adapted to circumstances. If there is an opening at the base, the lower part of the chimney can be treated like an ordinary basal cavity, being filled with concrete. Above this point, if there is a fairly large stretch of trunk without openings, it can be filled with packed cinders or gravel, and then a filling of asphalt can be set in at the top of the cavity. To fill the entire trunk of a hollow tree with concrete, to try to "put in a new back-bone," as one firm of tree surgeons has claimed it could, is at once wasteful and futile.

In case, for any reason, it is not desirable or feasible to fill the upper part of the chimney with cinders, it can be left open, and the filling of the top opening can be supported on a platform built just below it. Such a platform can be made of boards on bolts run through the trunk, or the platform can be made of wires woven back and forth between a dozen nails or staples driven into the inner wall of the cavity. Over the boards or wires any material or combination of materials (such as boards, straw, heavy paper, or burlap) can be used as a support for the filling of concrete or asphalt. But tinning is usually the best way to handle the top of a chimney cavity.

Chapter X

THE TREATMENT OF CAVITIES WITHOUT FILLING

THE tree surgeons have one almost universal characteristic. They all decline the half loaf. If they cannot have the whole loaf, they will have none. If they cannot do a perfect job, get all the decay out of the tree and replace the destroyed wood with a neat filling, they will not touch it. At least, so they say. If there are ever published the " Confessions of a Tree Surgeon's Foreman," perhaps we shall discover that, more often than we have ever guessed, they have been content to receive several good slices less than the whole loaf. A coating of tar and a filling of cement can cover a multitude of sins. Be that as it may, the writer believes that, though in many cases decay cannot be completely removed, there are few cases in which the progress of decay cannot be retarded, or at least in which the final result of the decay, the destruction of the tree, cannot be materially postponed. The ways and means of accomplishing these ends constitute the subject-matter of this chapter. There are also included in it discussions of various methods of treating cavities which premise a complete excision of the decayed wood, but which do not call for the filling of the cavity.

The most important way in which the life of a tree in an advanced stage of decay can be prolonged is by severe pruning and liberal manuring. The pruning takes off much of the strain on the tree and invigorates the remaining parts. Although this treatment does not, strictly, fall within the legitimate field of this book, on account of the vital interest of the subject to almost every person who is likely to look into a book of this kind, I shall venture to quote here a few lines from two editorials, written by the editor, Prof. Sargent, which appeared in the old "Garden and Forest."

"The vigor of a tree depends upon the power of its leaves to elaborate plant food. The larger the leaf surface exposed to the light, the greater will be the vigor of the tree. The object of pruning, therefore, is to increase leaf surface. If half a branch of a decrepit tree, bearing small and scattered leaves, is cut away, the leaves which will grow upon the half which is left will be so large that their total area will often be more than double the total area of the leaves upon the whole branch before it was cut. . . . A tree on the decline should have its main branches all shortened in from one-third to one-half their length. . . .

Nearly all our forest trees bear severe pruning of this sort, and improve under it." Prof. Sargent also insists on the importance of fertilization.

It need hardly be said that these extracts do not constitute complete advice as to when severe pruning ought to be employed, nor full directions for carrying out the work.

This is one way in which the arboriculturist, recognizing the impossibility or the prohibitive expense of eradicating completely the decay in a veteran tree, can defer the time of its dissolution by a much less expensive, and yet perhaps no less effective, treatment. Yet it would not do to create the impression that severe pruning and filling are alternative processes. If it is thought that the tree will respond to the pruning treatment it should be pruned. If, in addition, filling the cavities promises to be successful and not too expensive, the tree should be filled.

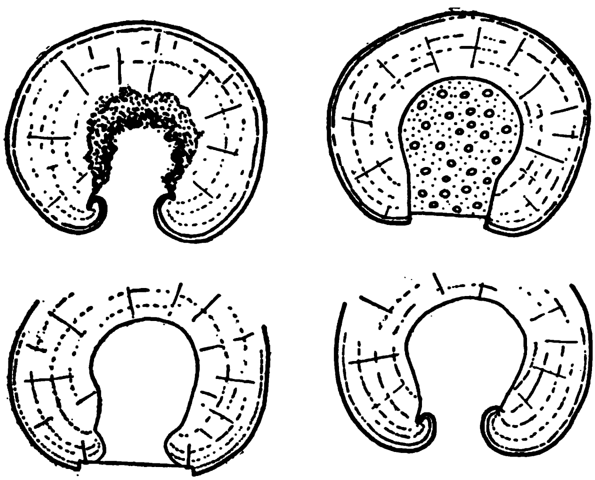
There are treatments, however, which are alternatives to filling and which fall within the realm of tree repair. Their purpose, for the most part, is to secure those benefits of cavity filling which are most cheaply attained, while sacrificing those less easily secured. Some are baldly practical, seeking only to stop decay and giving no thought to the appearance of the tree when the work is done. Some of them, though not including fillings, have been brought forward with the claim that they perform all of the functions ascribed to fillings, and perform some of them better than fillings do. Where the complete eradication of the decay is obviously impossible, or where, on account of the secondary value of the tree, or any other of the reasons enumerated in the sixth chapter, a large expenditure is not deemed wise, the weakening of the tree can be retarded by treatments which, makeshift though they be, often return larger percentages of benefit than do the far more expensive fillings.

There is at present a strong movement among practical arboriculturists, the men connected with experiment stations and with large city parks, in favor of the omission of the filling in the treatment of cavities. "Clean out every particle of decay, brace the trunk if it needs it," they say, "paint the interior of the cavity with a heavy dressing, and let it go at that." The arguments in favor of that method are four. First, it saves the cost of the filling. Second, there is less damage to the tree, because no sound wood need be cut away in preparation for the filling. Third, it does not suffer from the disadvantage of a cement filling that it "draws" water and increases the probability of a reinfection of the wound. Fourth, it does not suffer from the disadvantage of all fillings, that it is impossible to inspect the work after the filling is in place to determine whether further excavation is necessary and, if so, to continue it. This is easy when the filling is omitted. The cavity is inspected annually, and if there is any decay it can be removed.

On the other hand it is claimed that several advantages attained by the filling are lost by omitting it. First, no provision is made for the support of the callus, which, without support, cannot bridge the wound. Second, the provisions against the entrance of insects and fungi are inadequate. Third, the strengthening effect of the filling is lost. Fourth, if the excavation is a large one it will invariably ruin the beauty of the trunk of the tree.

In answer to these claims the "ultra-modernists," to borrow a phrase from a rather remote field, assert, as to the first of them, that in the case of large wounds in old trees callus growth is so slow as to be negligible, and that when calluses do grow, they help the tree quite as much physiologically and almost as much physically when they roll into the cavity as when they bridge over it. Of the second claim they say that a heavy dressing, periodically renewed, is as good as a filling, and of the third, that the strengthening effect of the filling is highly problematical and cannot be great in any case. As regards the esthetic argument, they frankly admit that they are not working for looks but for effectiveness.

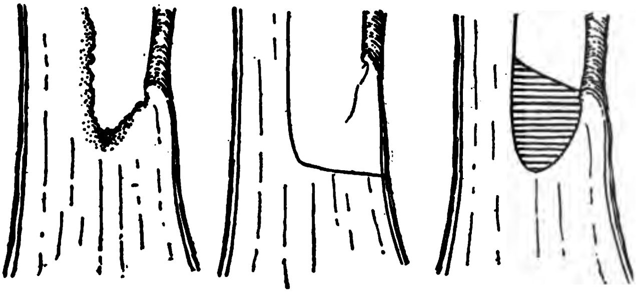
As to the technique of the "open system," but little need be said. The excavation is made in substantially the same way that an excavation for a filling is made, though with the important differences that no wood has to be taken out of



Four sections of the same cavity, showing it before excavation, filled with concrete, covered with zinc and treated by the open system

it so as to shape the excavation in such a way that it will retain a filling, and that no provision has to be made for a "cambium edge line" from which the callus can grow out over a filling. Ingrowing calluses need not be removed. If incisions through the healthy bark have to be made they should conform in shape and location to the rules for making incisions formulated in a previous chapter. No tongues or patches of bark can be left, which are cut off from the main flow of sap, for they will die, decay, and expose the wood. Drainage must be looked out for. If a "pot" is left at the bottom of the cavity it must be filled.

The best way is to pack in some largish stones



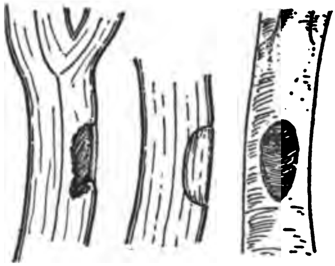
Two ways of handling a "pot" at the bottom of a cavity treated by the open system

and submerge them with hot asphalt. Though, theoretically, if the pot is correctly painted it will be water-tight, so that water standing in it would do no harm, it might do some damage with the help of Jack Frost, and would be sure to become a breeding place for mosquitoes.

The dressing of the interior of the cavity must be done with the greatest care. After a coat of hot carbolineum, put on one or two coats of coal tar or of one of the asphalt preparations, seeing that not a speck of the wood is left exposed. Inspect the dressing yearly.

The open system is especially suited to the treatment of small cavities in healthy trees. Such a one is illustrated in the accompanying drawings.

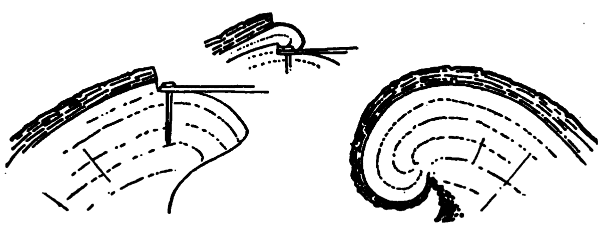
One of the first methods of dealing with wounds and cavities was to cover them with sheet metal.



Shallow decayed spot gouged out and tarred, without filling

The idea was not only to keep out the elements and insects and fungi, but also to provide a support for the calluses growing from the sides of the mouth of the cavity. It was at one time generally thought that tinning would prove the best treatment for almost every type of cavity, but it is now realized that its value is rather strictly limited. These limitations follow directly from the nature of the material and the way in which it is applied, and a discussion of them will be deferred until those points have been taken up.

The kind of excavation required in order to prepare a cavity for tinning is in some ways like an open system excavation, and in other ways like excavation for an asphalt or concrete filling. No provision need be made, of course, for the retention of a filling. But fitting a cavity for tinning is unlike treating it by the open system in that a line all around the opening of the cavity must



The correct way to cut an old callus in preparation for tinning and manner in which one new callus will spread over the tin

be laid out, up to which the tin shall come, and all living bark and cambium inside of this line must be removed. This line must keep as close to the cavity as possible, so that the area to be callused over may be minimized. The opposite sides of the line must be as nearly as possible in the same plane, so that the tin can be put on without wrinkling it. And the line must be so located that there shall be just inside of it a strip at least three-quarters of an inch wide, of fairly level, strong wood, upon which to nail the edges of the metal.

It is absolutely essential that no growing bark be permitted to remain inside of the cavity, for it would be almost certain, ultimately, to press against the lower surface of the tin and displace it. And it is especially important that the edges of the metal be laid and nailed in such a way that no growth can get under them, and in such a way that a callus will grow over them and the nail heads as soon as possible. The way to make sure that no living bark is left is either to chip off the bark and wood just under it, or else, as in the case of old inrolling calluses, to peel off the bark and to scrape away all of the exposed cambium. It is desirable, at the line at which the tin meets the bark, that a little of the sapwood be cut away, so that the tin may be a trifle below the starting callus.

As an interior dressing, a thorough coat of carbolineum will be enough. No heavier dressing is required, for there is no weathering to be guarded against and no bond to be produced between filling and wood.

Several different forms of sheet metal are used in tinning trees, tin itself, odd as it may sound, being the least valuable. But the word "tin" is so very handy, both as a noun and as a verb, that it is the natural one to use in speaking in a general way of sheet metal.

Sheet zinc comes in several degrees of hardness,

Linden on Boston Common, treated by the "open" system. The tree was so badly damaged by the leopard moth that it was not considered worth filling

a rather soft grade being best suited to tree work. The most useful thickness is No. 9 zinc gauge, which comes in sheets and rolls of various lengths and costs not far from seventy-five cents a square yard, retail. Heavier and lighter, as well as harder, zincs have their uses.

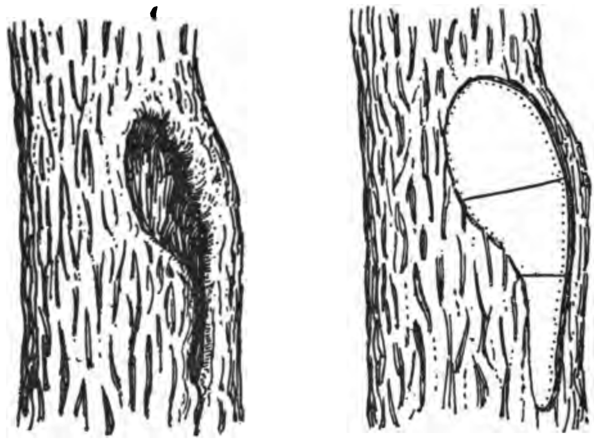
Galvanized iron is of course zinc-plated sheet iron. It is heavier and stronger than sheet zinc and is valuable for large flat work. No. 22, sheet iron gauge, is a good weight. It comes in sheets two feet by seven, which cost about two dollars.

Soft sheet copper is a pleasant material to handle and is a good material for covering wounds where much bending and fitting is required. It is the most permanent sheet metal, but is of course not strong. It cannot often be substituted for zinc on account of its high cost, the thickness weighing ten ounces a square foot costing about a dollar and a half a square yard.

Tin-plated sheet iron (roofing tin) does fairly well for small jobs where there is not much strain and where it can be kept painted. The weight stamped IC is the one oftenest used.

Ordinary sheet iron, such as is used for making stove-pipes, is the cheapest sheet metal, but it requires extraordinary precautions to prevent rusting, and one is never quite sure of it. The nails used are zincked shingle or basket nails, with fairly large heads.

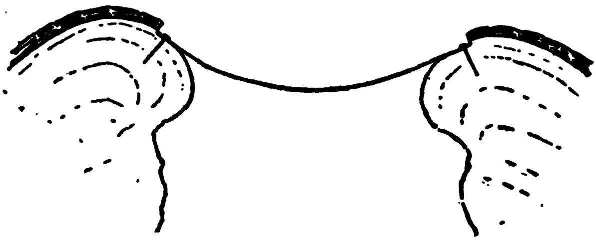
The way in which the metal is applied to the opening of the cavity is governed by the nature of the strains on the metal, after it is in place. Those strains have two origins. The pressure of the ingrowing callus upon the tin produces one kind of strain, a strain which falls first on the



Before-and-after views of a typical job of metal work

nails and then on the metal itself. This strain is not often the source of trouble, for as soon as the callus grows over the nails they are so anchored that they cannot give way. The other strain is far more serious. It results from the tearing and shearing forces produced by the bending and twisting of the tree. If the opening is a large one, in a storm its sides will shorten and lengthen, spread apart and come together. If this strain is too great it rules out the use of metal. A moderate amount, however, can be accommodated in various ways.

The first thing that can be done is to reduce the amount of strain on the metal by bracing the sides of the cavity together, exactly as is done in preparing a cavity for a concrete filling. If



Cross section showing how zinc can be bowed in to allow for spreading of the sides of a cavity

there is a good, strong nailing edge at each side, a few narrow strips of sheetiron can be nailed across the opening to help keep it rigid. The strain can also be met by dividing the metal up into sections of greater or less size, according to the amount of sway. When that is done the work must begin at the bottom, each successive section being lapped over the one below it an inch or two.

Under certain conditions the tendency of the nails to tear through the metal under stress can be lessened by bowing the metal in a little so that the spreading of the sides of the cavity is accommodated by the surplus metal.

When the incision is completed and everything is ready for the tin, proceed as follows: Make a paper pattern of the whole opening, if it is small, or of the lowest section if it is large, making sure that the paper is not stretched or folded in a way the metal itself is not capable of. Lay the pattern on the metal, scratch with a nail the line of its edge, and cut out the shape. Fit the metal over the opening, trimming off the edge here and there if necessary to make a perfect fit. Paint the back of the tin with tar or paint. Paint the edges of the opening, the strip of wood, that is, to which the tin will be nailed, with heavy liquid asphalt. Now fit the tin into place and tack it there with nails four or five inches apart. If the metal is heavy it is a good idea to punch holes around its outer edge with a small punch or a sharpened spike. The nails must be very near together — an inch or even as little as half an inch apart. Where circumstances permit it, stagger the nails, putting some farther from the edge of the tin than others. After nailing it is a good idea to go over the edge of the metal with some such tool as a dull cold-chisel, pounding the edge into the wood a little so that the growing callus cannot by any chance get under it.

It is hardly necessary to say that this work is not so easy as the simplicity of the above directions would indicate. A great deal of ingenuity is required to fit the metal neatly and closely. For instance, in order to make it conform to a "valley" it must sometimes be slit in from the edges and overlapped.

The treatment of the outer surface of the metal is the last but by no means the least important process in tinning cavities. A very heavy dressing should be put on, especially around the edges. Not only is this last necessary as a precaution against the entrance of water, but also against rust, especially of the nails. A heavy dressing also tends to prevent the starting of the nails in zero weather.

Tin work requires a certain amount of after care, like every other sort of work in trees. The surface dressing may need renewal after a few years. There is one objection to tinning which may have to be remedied if it develops. That is the tendency of the tin, or such other metal as may be used, when there is a high breeze, to "snap," a noise which means that the tin is being forcibly, though slightly, wrinkled. After a year or two the tin gives way in one or two places and the noise stops. As soon as a piece of tin begins to snap one or more horizontal slits must be cut in it with a can opener or a sharp cold-chisel, so as to relieve the tendency to buckle. The slits must be covered with cotton-batting soaked with an asphalt dressing. It is likely that a back filling of cinders or sawdust would help to avoid the disadvantages of tin work, but the writer has never tried that method.

The nature of the principal strain upon the metal and the way in which it gives way to it, suggest the correct limitations to be placed upon the use of metal for covering cavities. It is not so much size which causes the failure of a job of tinning, but rather the amount of variation there is, under stress of the wind, in the size and shape of the opening. A large cavity in a firm trunk is much easier to tin successfully than a smaller cavity in a bending and twisting limb. An opening in a trunk or branch which swings about much ought not ordinarily to be tinned, as the work is almost certain to be unsatisfactory. It is sometimes difficult for a beginner to determine whether a given opening is likely to be variable in size or not. In that case it is best to wait until a windy day comes, when any variation in the size of the opening can be observed.

Tinning is very well suited to the treatment of small cavities, such as those resulting from the decay of stubs. The treatment of one form of rotten stub, for which tin is especially well adapted, is indicated by the accompanying drawings. Metal does very well as a covering for the oval cavities resulting from the partial healing and partial decay where a limb has been torn away by the roots, as so often happens in elms and silver and red maples. It is often the best way to handle the top of a chimney cavity. It is all right for cracks which do not open and shut. It is not suited to the treatment of large, long, and contorted cavities.

In several different connections, I have spoken

Hollow stub cut off close and covered with tin

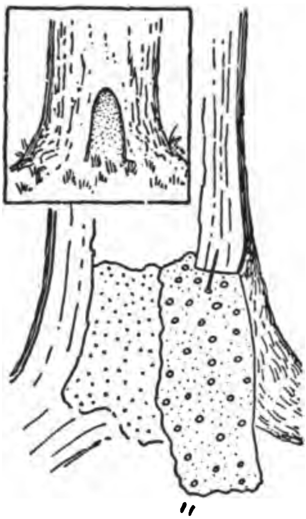
of decayed trees which could not or ought not to be cleared entirely of rotting wood. There are two reasons why this may be the case. First, the decay may be of such a character, and may have spread to such an extent, that its complete removal would involve a prohibitive expense. Second, for similar reasons, the complete removal of the decayed wood (retaining, as it does, a certain degree of strength for many years), and the removal of large amounts of sound wood in getting at the decay, may promise to involve a greater risk of damage than is involved in the presence of the decay. The basic principle we have so far been working on is that the purpose of cavity work is to stop decay, and that decay can be stopped only by the complete excision of the contaminated wood. Is there anything, then, which can be done if complete eradication is impossible? To this question, I believe, an answer, provisional perhaps, can be made in the affirmative. Decay undoubtedly progresses at different rates under different conditions. Weather, moisture, and insects favor the destruction of wood by decay; dryness and freedom from the attacks of insects retard most types of decay. Many rot-producing fungi work so slowly that the infested wood retains a fair amount of tensile strength and a very considerable amount of compressive strength for a great many years. It is worth while to prevent, as long as possible, the complete disintegration of this dead wood through the activity of insects and of "follow-up" fungi and bacteria. As to this last point very little is definitely known, but it is probable that bacteria are very important in the final bieaking down of decay-infested wood. Moisture, it is well known, is essential to the growth of bacteria, as of other fungi.

There are times, then, the writer believes, when it may be profitable simply to treat a cavity so that insects and moisture may be kept out in so far as is possible, and that the conditions may be made as unfavorable as possible for the growth of fungi and the oxidation of wood. There are several ways in which to go about the application of this principle. The first step is to remove all loose decayed wood, and to impregnate the remainder with a moisture-repelling preservative such as hot carbolineum. In order to do this effectively, it is usually necessary to let the cavity dry for a few days, or else to char it out with a gasoline torch. If the carbolineum is brushed on it must be dashed into all the cracks. At least one coat should be sprayed on, if possible. The first thing to be attended to, however, is the drainage of the cavity, if it needs draining. An incision can be made to accomplish this, or, if there is a " pot " to handle, the decayed wood in it can be cut and burned out, and it can be filled with stones and asphalt.

If a hole runs up the tree it should be cleaned out as well as possible, sprayed with carbolineum, and blocked up in some way. An old sack, or a sack full of excelsior or straw, the whole thing dipped in carbolineum, might fill the bill.

If a cavity so treated is located in such a way that the rain cannot beat into it there need be no covering over the mouth to keep out the weather. Indeed, light and ventilation are likely to retard the growth of the fungus. If the mouth is horizontal, on the other hand, it may be well to tin over the opening. The tinning, of course, must be just as well done as if the cavity had been thoroughly excavated.

For blocking a small hole at the base of a hol-



Plug of concrete at base of chimney cavity

low tree, nothing is better than a plug of concrete, held in place by nails driven into the wood a couple of inches back from the opening. An incision must be made, and the filling must be kept back from the cambium line, just as in ordinary fillings.

It perhaps had better be said again that the processes last described are not advanced as the correct treatment for valuable and historic trees, but when used in the woods or orchard, where more effective treatment is economically or technically out of the question, they are well worth their cost, if only to prevent the breeding of boring insects.

CHAPTER XI

BRACING

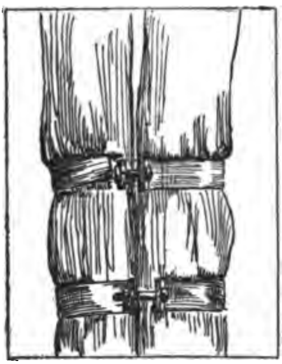
THE bracing of trees is one of the most important phases of tree repairing. Most trees which reach maturity die through being uprooted or broken down. If a tree breaks off bodily the trunk is usually rotten, and rotten trunks are most often caused by decay entering through wounds caused by the breaking-off of branches. Thus bracing may prevent decay. Even if decay has set in, bracing may put off for many years the inevitable result of the destruction of the tree's framework. The vitality of trees is wonderful. Hollow old apple trees and chestnuts which look as if the next strong breeze would blow them over, will flourish for years. Hollowness does not necessarily mean physiological weakness. Even if the heartwood, which is dead and mere support, is eaten away, the living, sap-conducting wood may be intact. If, then, we use a few rods of iron and lengths of wire rope to perform the function normally performed by the heartwood, the tree's "expectation of life" may be as good as if it contained no decay.

The question of when to brace is not easy to answer. A limb requires bracing if serious decay appears in it or in the trunk from which it springs; if a bad crotch has developed; or if, for any reason, including natural growth, the load supported by the limb has increased to such a degree in comparison with its strength as to make it look, and be, "dangerous." A tree as a whole may require bracing if trees near-by which have protected it from the wind have been removed, if the tree's foothold has been weakened, if its trunk is decayed, if it has lost large branches and become lopsided, or if structures have been placed beneath it which would make its fall especially disastrous.

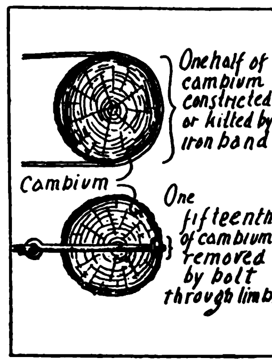
Some kinds of trees require bracing oftener than others. The fruit trees lead, and especially the apple, with its long horizontal branches. Trees which form close crotches, as the silver maple and elm, and weak-wooded trees, as tulip, linden, willow, and some maples, are especially apt to need preventive or corrective strengthening.

Judgment, careful investigation, and observation under stress of ice-storm or full crop, must supplement the above rules as to when to brace. In any event, the presumption should be in favor of bracing. It is good insurance, like the stitch in time. A few dollars' worth of iron, though not essential now, may some day save you the loss and sorrow caused by the destruction or mutilation of a beautiful tree. If you are in doubt as to whether to use cement filling you may wait a year. The decay will spread but slightly. But if bracing is needed, do it at once, for the next storm may wreck the tree. And never depend on cement as a substitute for bracing.

In coming to the methods of tree bracing, it is



Two bands, one now broken, around limb of a sugar maple



Showing how a bolt put through a limb, kills less cambium than a band

necessary to dispose, first of all, of an old idea on the subject. It has long been the custom to strengthen the spreading limbs of old trees, especially elms, by binding them up with a chain or iron band, just as one would tie up with a string the stalks of a sprawling hollyhock. These bands usually break. If they do not they often break the limbs they are supposed to strengthen, for they kill the bark and stop growth where they impinge on the limbs, and wear their way far into the wood. Any brace which wholly or partly constricts the growth of a limb defeats its own purpose, for it prevents by just so much the natural strengthening of the limb. There is no reason why a tree should have to wear corsets.

The great point is that the nourishing sap, as we have seen in the second chapter, flows down the delicate cambium just beneath the bark. If the cambium is killed, growth at that point ceases, and decay begins. If a band is used, a strip of cambium is killed which amounts to from a fourth to a half of the circumference of the branch. If a bolt is run clean through the limb, the nut being sunk into the wood, perhaps a tenth of the circumference of cambium will be removed, and this amount will be quickly reduced as the nut is grown over. No system will therefore be proposed which requires the removal of any considerable amount of cambium, measured on the circumference of the limb. Narrow incisions into the cambium made parallel to the length of the limb heal rapidly and are comparatively harmless.

Another general principle is that the brace should be as high up as is possible, or, at least, as is convenient. This follows from the physical law of the lever and the fulcrum. A brace near the crotch has to be much stronger than one which is farther from the crotch. Light materials can be used for rather heavy jobs if this principle is employed.

As a rule the brace should not be pulled up taut. If chain or wire is used a little slack should be left, and long rod-iron braces should always be jointed. The reason for this is that a branch can normally sag a few inches without danger, and it is only when this safe elasticity has been used up that the brace is needed and should come into play. At this point the strength of the brace is added to the strength of the limb. If the natural sag of the limb is not permitted, the brace must assume the entire strain the moment an unusual burden is placed on the limb. The amount of slack required depends, of course, on the distance of the brace from the crotch. Where the purpose of the brace is to close up a crack obviously no slack can be allowed.

Various materials are used for braces. Formerly, chain was much used. It has the advantage of being rather easily applied, if hooked bolts are used, but is expensive, conspicuous, and easily rusted. Rod-iron is equally expensive, very difficult to adjust, often noisy, and requires frequent trips to the blacksmith's while work is in progress. Of late years the writer has come to depend on heavy wire for light work and the various sizes of steel wire rope for heavier work. This ma-

Willow in Longfellow Park, Cambridge, Mass., showing how an iron band constricts the tree. A bolt through the limb should have been used

terial is very strong, inconspicuous, and extremely economical, both of material and labor.

The wire is normally used to connect laghooks or eyebolts fixed in the branches to be braced. In large jobs the strength of the wire must be made approximately equal to the strength of the anchoring material. It is wasteful, for instance, to use wire rope with a strength of two thousand pounds to connect eyebolts which have a strength of only one thousand pounds. A lighter rope should be used.

The simplest form of brace is a straight bolt through the trunk of a splitting tree. In the case of young trees this treatment alone may cure a dangerous crotch. I shall state with care the method of inserting such a bolt and in subsequent descriptions shall take for granted an understanding of the proper way to insert a bolt in a tree.

First decide on the size of bolt to be used,—a quarter-inch, say, for a four-inch sapling, or five-eighths for a tree of ten inches or so. Then with a bit of the same size, bore a hole through the tree, choosing a place where the wood is thick and strong, and where the hole will be nearly perpendicular to a fairly level and clean surface at both ends. Now take a chisel and cut out a shallow coffer or depression into the wood at one end of the hole. This coffer is to receive the square head of the bolt, for machine-bolts and not wagon-bolts are used. It must be just the size of the bolt-head and its floor must be at right angles to the hole, regardless of the bark. It may be shallow or deep, but must be sunk through the bark and at least an eighth of an inch into the wood.

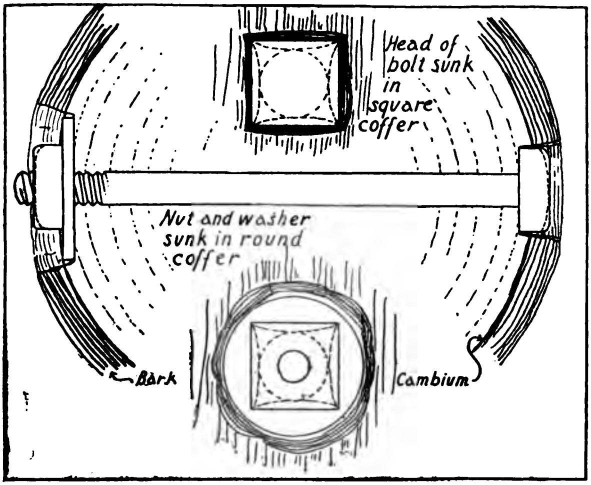
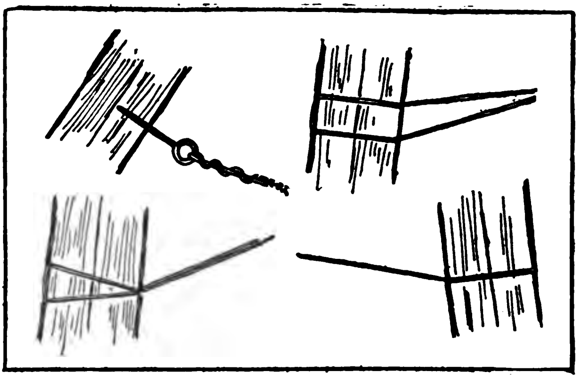


Diagram of bolt through a limb, and views from above of both ends of the bolt

If the head is sunk in to the level of the cambium it will be quickly grown over, but that is an advantage of appearance only. A similar coffer, except that it is round, to receive the washer, must be made at the other end of the hole. Now run a wire or stick through the hole and get the length of the bolt. The bolt being selected or prepared, paint it and both coffers with tar. Drive the bolt through, apply the washer and nut, and tighten up. If much of the bolt extends beyond the nut it can be cut off with a cold-chisel or hack-saw. Now paint all exposed iron, and the work is done. Some very particular people fill up the coffers, to the level of the cambium, with putty, plaster, or cement, but unless they are very large they will soon be covered by a natural callus.

As a rule a single bolt should not extend through two branches, even though they be close together, because, if there is much sidewise movement, or twist, one of the branches will be split. However, when the two trunks of a bifurcated tree run up nearly parallel, the best way to brace them is usually to put a single heavy bolt through them, not very far above the crotch.

We will now turn to the bracing of the limbs of small trees. Apple and peach trees are especially liable, if not properly pruned, to develop long branches which are not strong enough to support large crops of fruit. Such limbs are usually propped, but bracing with wire is much more satisfactory. For such work fence-wire, or even baling-wire, doubled, will do very well, but wire which is not galvanized must be painted. Large screw-eyes can be used in the limbs or even more economical devices can be used. One of these is as follows: Bore a hole through the limb about twice the size of the wire. Run the wire through, turn the end and run it back. Adjust a headless ten-penny nail in the loop so that it will catch the wire as the loop starts to pass through the hole. The nail must lie lengthwise of the limb and it is just as well to cut a slot in the bark to receive it. This

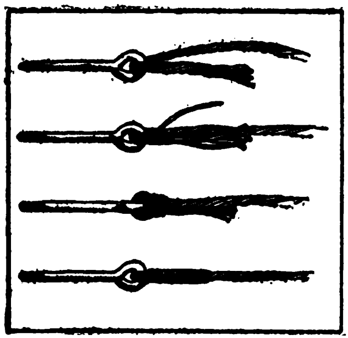


Cross sections through small limbs, showing four methods of fixing wire

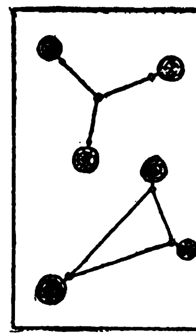
device is usually used with a double wire, but it can be done with a single wire just as well. Only two or three inches at the end of the wire is turned and pulled or driven back into the hole. If it is a tight fit and the wire is stiff the anchor will be as strong as if the wire were doubled throughout its length. Another scheme is to bore two smaller holes and run the wire in one and out the other. One hole must be just above the other—say three inches away. Another way is to bore two holes from a single point, one slanting up the limb, the other down. A slot in the bark from one hole to the other can be made to receive the wire, but care should be taken in pounding the wire into place not to bruise the bark. The nail or wire will be grown over in a year or two. If the hole is not filled up by the wire a bit of cloth dipped in tar might be pressed into it to keep out insects and fungus spores until growth closes the opening. Tree-doctors may say these schemes are not workmanlike, but they are effective, economical, and easily worked, and they don't hurt the trees.

If there are a number of weak branches they can be supported from a ring near the center of the tree. If two weak branches are opposite, with a strong trunk between them, a wire can be fixed to one, run up to the trunk, straight through it, and down to the other.

In larger work we must substitute wire rope for wire and eyebolts for screweyes or nails. Wire rope is made of steel and is not very easy to handle at first. It is better to begin with one of the smaller sizes before tackling three-eighths or half-inch. If you have a job to do with the cable, begin by preparing the holes, coffers, etc., for the bolts, and get the bolts ready. Then, on the ground, take the bolt which is to go into the place at which it is less convenient to work. Run the end of the rope through the eye six or eight inches. Bend over this end, using the hammer to pound it down. Then fray out the wire strands in this bent end. Pull up one strand and bunch the others down on to the rope. With a pair of pliers wind the detached strand around the bunch and the



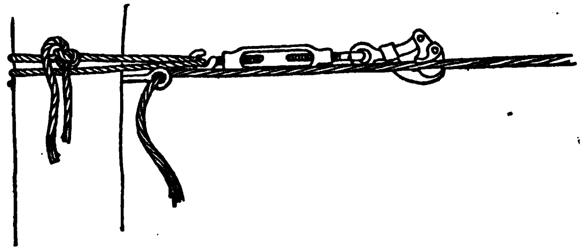
Method of splicing wire rope to eye bolt



Two methods of bracing three limbs

rope. When you come to the end of this strand, take up another and wind it around, and so on to the last. Now take the bolt, with the cable fixed to it, up into the tree. Drive it home and adjust the nut and washer.

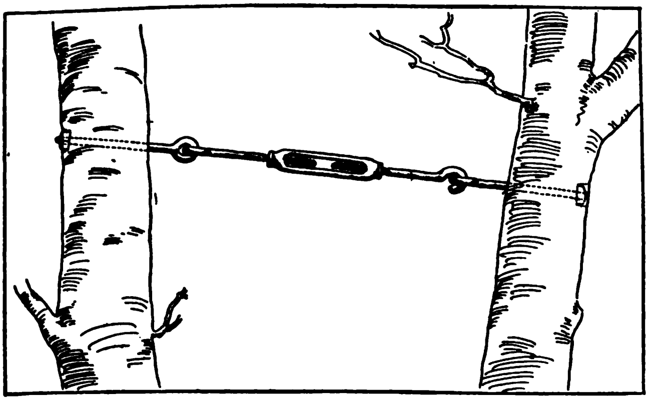
It is now time to go to the other end of the brace. Set the bolt in its final position. Cut off the rope with a foot or so to spare. With a block and tackle or a light turnbuckle and " come-along," tighten the rope, pulling it towards the eye of the bolt. Thread the end of the rope through the eye and proceed exactly as with the other. When the tackle is taken away this will leave just about the right degree of slackness in the wire rope. If it is desired to put a greater strain on the rope, the nuts on the bolts can be screwed up only two or three threads at first and tightened up afterwards.



"Come-along" and turnbuckle arranged for tightening up a wire rope brace

The only step in this process which requires special tools is the tightening up of the cable. The ideal outfit for this work is a long, light turnbuckle with two hooks, and a lineman's "come-along" to grip the rope. A grip can be secured in other ways, however, as by means of one of the smaller cast-iron (not stamped) tie-plates used by linemen to splice cables. The middle bolt of the tie-plate is taken out and a wire is looped through the hole, the turnbuckle being hooked over the loop. With the smaller sizes of cable a strong man can get usually a sufficient degree of tightness, especially if the limbs are drawn together a bit beforehand.

It is not practicable to lay down rules as to the sizes of bolts and wire rope to use in particular cases. About all that can be said is that heavier material than seven-eighths iron and half-inch wire



Eyebolts and turnbuckle are used to pull together two weak limbs when the strain is great

rope is not likely to be needed very often. Yet the strain produced by a long and heavy limb is very great and it is better to have the braces too heavy than too light.

If it is necessary to brace a large limb up stiff to the trunk in order to close up a crack or to take strain off a cement filling, an iron rod must be used. The rod must have hooks at each end, to hook over the eyes of the eyebolts. The measurements for the rod and bolts should be made with care and the entire operation should be planned in advance. Sometimes it is necessary to put a joint in the rod in order to make it possible to hook it over the eyes. The pulling-up can be done by tightening up the bolts, one of which should be given a long thread with this in view. Where a greater strain is required a turnbuckle must be inserted into the rods.

Considerable ingenuity is often required to find a proper support for weak limbs when there is no strong main trunk to anchor them to. The usual solution is to make limbs on opposite sides of the tree balance each other. Or, the braces can be made to radiate from a ring in the center of the group of limbs. It sometimes happens that the top of a tree is broken off and that the remaining limbs, which afterwards grow to considerable size, are practically horizontal. If such limbs need bracing, as they are apt to, a rod or tripod must be set up in the center of the tree to take the place of the trunk.

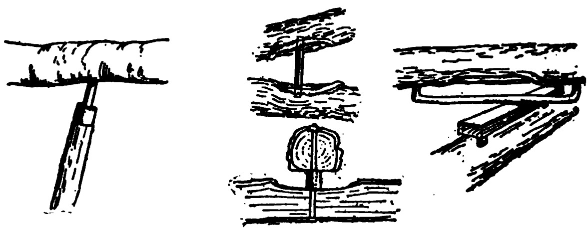
In a few cases braces are impossible and props must be used. The old forked-stick method does very well for light work, but where a large limb is to be permanently supported, a stronger device must be used, and one which is less liable to injure the bark. The best way is to use a pole with a short iron rod inserted in the end, exactly like an ordinary tent-pole. A hole is bored into the under surface of the limb and the iron rod is inserted, just as it is into the ridge-pole of the tent. If it is a tight fit the limb will be able to lift the prop in a windstorm without danger of the prop's falling. If the prop extends from one limb, or one tree, to another, both ends of the prop must be provided with correct contact points.

Not only do the individual limbs of a tree often require bracing, but trees as a whole are frequently so weakened or thrown out of balance that if support is not given them they will sooner or later be blown down by storms. The methods in this work are practically the same as those described for bracing limbs by the use of eyebolts and wire rope, except that heavier materials must usually be used. The main difficulty is to find proper anchors for the guys. In a grove other trees can be used, even if they are at a considerable distance. If no trees are available a short post may be necessary. Telephone and telegraph linemen have reduced this kind of work to a science and useful suggestions can be gathered from a study of their work, though of course they are not bothered by æsthetic considerations.

In bracing trees, especially from one tree to another, what has been said about the value of a little slack in a brace must not be forgotten.

Often the principal danger to a tree is from the twisting effect of winds. If the conduct of the tree in high winds indicates that this danger exists, an effort should be made to correct it by running braces from a neighboring tree, not to its trunk, but to its limbs.

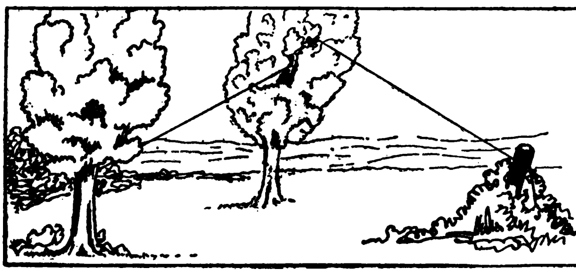
Although most bracing consists of bracing limbs together, occasion sometimes arises for bracing limbs or trees apart. This occurs when two trees



Showing correct method of propping a weak limb, and three ways of handling two limbs which rub against each other

or two limbs are so close that they wear against each other. The general rule in such cases is that the less valuable of the offenders should be cut out. Such heroic treatment, however, is often undesirable. If so, the thing to do is to brace the limbs apart. The most obvious way to do this is to pull the limbs away from each other by means of wires or rods running to other limbs. Failing this, one of several other solutions can be used. One way is to pull the limbs apart, bore a shallow hole in the worn surface of each, and put in a short iron rod to hold the limbs apart. Another way is to bore a hole straight through both limbs and run a bolt through, inserting a short length of gaspipe over the bolt between the limbs. This does very well if there is not much side-swing to the branches. In that case a different scheme must be used. A good way is to fix a couple of buffers to the limbs. They can be of iron if an occasional squeak is no objection. If it is, one at least should be of wood.

Bracing even has the unusual quality of sometimes being able to bring the horse back to the barn after he has been stolen. After a storm, especially an ice-storm, we often see a tree fairly crushed to the ground, though hardly a branch has been entirely broken away. The large limbs have been split down at their crotches but are still attached to the trunk by hinges of more or less splintered wood and wrinkled bark. It is often possible to pull such limbs back into place and save them with but little damage. The work should of course begin as soon as possible after the accident. Each limb should be lifted, with the help of block and tackle, and, possibly, a tripod of beams, and firmly braced into place. For this purpose, if much doubt is felt as to whether the limb will survive the operation, it may be well to use a temporary arrangement, tying the limb up (protected, of course, by slats of wood or bandages of burlap) with rope, wire, or chain. If there is any detached bark it should be bound to the wood with the hope that, even if the bark dies, the cambium will be saved to form a new bark. All exposed surfaces should be covered with one of the materials for preventing drying described in the chapter on wounds. If the leaves wilt badly the tree



Two ways of bracing an entire tree

should be watered (if it needs it) and the injured branch (but not the whole tree) should be pruned back more or less severely. If, in the end, one branch dies, it must be removed and all the wood which it has detached in the least from the rest of the trunk must be removed and the wound smoothed and dressed.

Even whole trees which have been wholly or partly uprooted can be straightened up and made to flourish again. Such a process affects the tree somewhat as transplanting does, and is most successful if it happens to be needed during the transplanting season. Good soil should be supplied the replaced roots and the tree should be watered and pruned, usually rather severely.

CHAPTER XII

THE PREVENTION OF WOUNDS AND CAVITIES

ENOUGH has been said about the difficulty, expense, and uncertainty of filling trees to make almost unnecessary any argument in favor of protective and preventive measures. And yet the slowness with which decay does its work, and the fact that the tree, lacking a nervous system, may give no indication in one part that another part is being eaten away, often blinds people to the danger which lurks in every wound in a tree. The prevention of decay is vastly the most valuable part of the work of tree repair. It pays back by far the largest return on its cost. It is the stitch in time which saves nine, and many times nine.

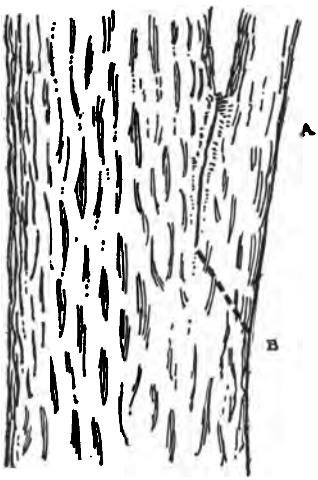
The work of prevention of decay falls into three divisions: making those wounds correctly which have to be made, dressing wounds, and preventing wounds.

The first phase is really within the realm of tree pruning. A very large proportion of the cavities which have to be filled, or which cause the ruin of trees, have their origin in the stubs left by wrongly sawing off limbs. Yet the fundamental rule of pruning is that every branch must be cut off close to the trunk or limb from which it is growing. The cut ought to be made so close that, seen in silhouette, it is hardly possible to tell at what point the branch was cut off. The reason for this is obvious from our study of the nature of the cambium and of the healing process. If the cut is made close to the trunk the forming callus is close to the main flow of sap. The cambium which is building the callus is well nourished and does its work quickly.

Vertical stub and correct cut

For the same reason, a main trunk which has to be cut off must always be cut just above a healthy limb, and usually not horizontally, but slantwise, not only so as to shed water, but also so that none of the remaining bark may be very remote from the current of sap flowing from the trunk into the limb. If an adventitious shoot, or water sprout, should appear at the lower edge of the cut, its healing will be accelerated.

A limb must be cut off at its actual base, which is sometimes not the apparent base, as often when a branch leaves the trunk at an acute angle. If when a limb is removed the resulting wound is heart-shaped, and a little pocket remains just behind the notch of the heart, the wood in front of the pocket must be removed with a gouge. Indeed, a gouge is rather frequently needed to

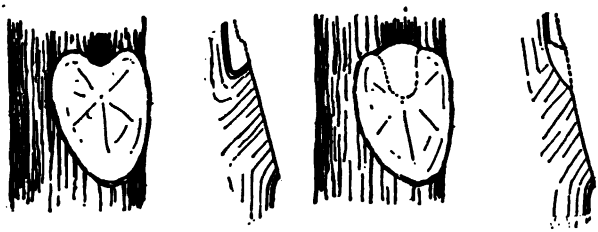


The apparent base of the limb is at "A" but the real base is at "B," where the cut should be made

supplement the work of the saw in so shaping pruning wounds that they can heal normally.

Fungi enter wounds mainly through season checks and at the lowest part of the wound, where the drying of the bark and the starting of a callus often expose the wood just below the bottom of the cut, and also form a pocket in which water stands and decay begins. Hartig calls this point "the Achilles heel of a branch wound." It should be specially attended to when the wound is given its second dressing. Similarly, the bark at the bottom of the opening of a filled cavity should be notched with a gouge to let the water drain out of the trough which is pretty sure to be formed between the bark and the wood.

The rule as to close pruning does not apply to

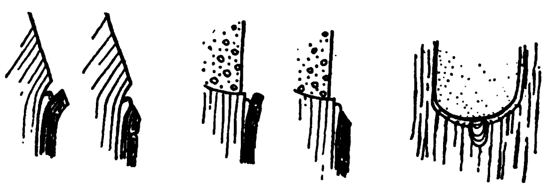


Pocket above a pruning wound corrected by the use of the gouge

roots. They should be left as long as possible, if they are in good condition, unless they have to be cut off very close to the tree. In that case they should be cut as close to the trunk as possible, if necessary by using a gouge. The wound should be carefully dressed. A good material for this purpose, as well as for longer roots which are very large, is hot carbolineum. After following this with a heavier dressing a few shovelfuls of cinders should be thrown against the root to drain the cut surface. All large roots should be cut square with a saw.

As to the technique of dressing wounds enough has been said in the chapter on wounds. There is one aspect of the matter, however, which seems to fit better into the present chapter, and that is the systematic treatment of wounds in large grounds, in parks, and in orchards.

The importance of this work was first brought



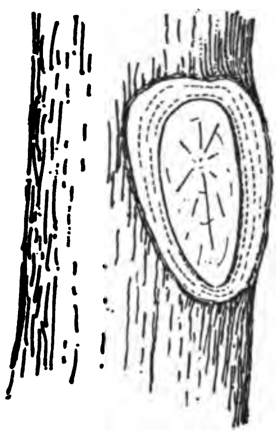
Sections and front view showing the dangerous pocket which forms at the base of a wound, and the way the bark must be cut to drain it

to the writer's notice a number of years ago, when he was employed as foreman on a large California citrus-fruit ranch. The bark of orange and lemon trees is thin and rather fragile. During the constant plowing, cultivating, and harrowing which take place in an orchard under irrigation, the trees, especially the ones at the ends of the rows, are often barked, even by the most careful drivers. Prompt treatment of such a wound will usually result in the growth of new bark over its whole, or nearly its whole, area. This was explained to the men and they were instructed as to the proper treatment of the wounds. At the corner of each "block" (ten acres) a bottle of shellac and one of liquid grafting wax, and a bundle of rags were hung in a tree. When a man barked a tree he went at once to the nearest outfit and got the bottles and some rags. Then he trimmed away the loose bark with his knife, poured out some of the wax on a bit of cloth, and spread it (the wax) over the wound. Finally, he bound the wound with cloth and smeared the cloth over the wound with shellac. Even the California sun could not dry out a wound so treated, and most of them healed perfectly.

Some such system as this should be in force in every large grounds and in every orchard. For the most part, however, it will be sufficient to have a single repair outfit kept, always ready for use, at the barn or toolshed.

In addition to this emergency treatment, there ought to be a thorough yearly inspection and treatment of all valuable trees, be they along the street, or in park, grove, or orchard. The time at which the yearly round is made is of little consequence. A fairly complete outfit is essential. A box like a carpenter's nail box makes a handy arrangement to carry things around in, the tools on one side and the dressings on the other. The tools likely to be handy are a pruning saw, preferably of the meat-saw type, with a blade which can be set at right angles to the back, making it possible to take stubs out of crotches; a gouge and mallet; a sharp knife, and, if borers are to be tackled at the same time, the wire and other tools recommended in the chapter on insects. Of dressings, liquid grafting wax (not likely to be used so often, however, as in emergency operations), shellac, and tar, paint, or some form of liquid asphalt, will be needed, and such things like putty, carbon bisulphide, and the like, as may be needed for special purposes. Every tree must be carefully inspected from its roots up. If it is a young tree and there is high grass growing around it, pull the grass away, and make sure that the base of the trunk has not been gnawed by mice. Inspect the bark, to see if any part of it has been killed by canker, frost, or sun-scald. Keep a sharp lookout for sporophores, dull patches of bark, and other signs of the presence of fungi. Look for borers. If the tree has been repaired, see that all fillings and dressings are in good shape. If old pruning wounds are checking, give them another coat of paint. If calluses are growing over any of the wounds, see that borers are not getting into them, for several kinds of borers make a specialty of tender calluses. See that cottony plant lice are not gathering under the lip of the callus, suck-ing its sap and deforming its growth. Slit the bark of the calluses.

This last direction may require some explanation. In the second chapter, dealing with the nature of the growth of trees and the way in which wounds are healed, it was brought out that growth



Callus slit along the dotted lines to accelerate its growth

normally proceeds fastest where bark pressure is least. It is that very fact which explains the growth of a callus. At first the callus grows very rapidly, but as the bark covering it gets thicker, growth becomes slower and slower. Finally, the callus may become "bark-bound," just as a tree sometimes does. As it relieves a bark-bound tree to cut slits in the bark, so a slow-growing callus can be relieved by slitting the bark of the callus. There is this difference, however, that the bark of the callus need not be bound, in order to profit by the slitting. Even a rapidly growing callus of one or two years can be made to grow even more rapidly by cutting through its bark. Indeed, I have sometimes cut a callus twice a year, once in May and again in July, with obvious advantage. It is really surprising how rapidly a wound will be healed over, if it is close to the trunk of a healthy, growing tree, and the callus over it has its back scratched occasionally with a sharp knife.

The method of operating is simply to draw the point of a sharp knife around the callus, parallel with its edges. The cuts can be made not only on the inner face of the callus, near the wood over which it is spreading, but also farther back. The writer usually uses a number of short cuts rather than entire circles.

The best way to deal with the question of wounds in trees, after all, is to prevent the trees from being wounded. The great majority of wounds are due purely to carelessness and ignorance. They can and should be prevented by intelligent pruning, and by protecting the trunks of trees which are exposed to extraordinary dangers.

If a tree is pruned rationally at not too great intervals from the time it is set out until it reaches maturity, the necessity need not often arise for cutting large limbs. Pruning can also largely prevent the formation of bad crotches. Both these ends are attained mainly through care to prevent the formation of too large a number of branches from the main trunk during the tree's formative period. Limbs which wear against each other must of course be eliminated as soon as they are noticed.

Bracing is another very important prevention of the formation of bad wounds, and of splits and crotches which give the spores of fungi entrance to the heartwood.

There are a vast number of petty ways in which trees receive injuries which are entirely unnecessary. Such, for instance, as driving spikes into them to tie the clothes-line to, nailing signs to them, using them as supports for fence wire and chicken netting, and setting plank seats between pairs of trees. These small vandalisms must be absolutely stopped if the health and beauty of the trees are to be preserved. A few nails, to be sure, won't damage a tree much, but they hurt it a little, and they are a standing invitation to further maltreatment.

Another large class of wounds has its origin in bruises to the trunks of trees by tools and wagons. On the lawn the greatest offender is the lawn-

Small cavity in white oak correctly filled with concrete

mower, or rather the man behind it. It is astonishing how otherwise good gardeners will complacently bang a machine against the trunk of a tender-barked young tree. On many fine estates nearly every tree on the lawn bears near its base the ugly and dangerous memorials of the confirmed contempt of gardeners for anything but their own planting. The cure for such a condition of affairs is not far to seek. Every man on the place should be impressed with the importance of avoiding wounds and should be made to attend immediately to every wound he causes. If a man proves to be quite unreformable the only thing to do is to order him to wrap a gunny-sack around the base of every tree on the lawn before he starts to mow it.

In the orchard whiffle-trees and cultivator wheels do most of the damage. Here again, remedial measures can be effectively applied to the human element, although short and specially designed whiffle-trees are an important aid to careful work.

The necessity of placing stout guards around trees in pastures need hardly be insisted on. The guards should be of ample size, and so built as to protect the roots of the tree. Pigs, and especially boars, are very destructive, and when they are permitted the run of the orchard the trees must be protected, either with guards of wood or poles, or with bundles of thorn branches wired closely about them.

Trees growing along streams are very frequently hollow, the result of the work of fungi which enter the trunk through wounds made in the bark by floating ice during spring freshets. In bottom lands, trees a considerable distance from the river are sometimes thus affected. If such trees are valuable all but the oldest and toughest-barked must be protected, as by poles tied around the trunk with wire. The guards can be put on in winter and taken off in May, or they can be left on for several years at a time. On a large scale, it may be necessary to grow willows and birches to protect the standard trees.

It is in building operations, however, that the most pitiless slaughter of the innocents takes place. Graders seem to think only of their grade, builders only of finishing their work at the time specified in the contract, and teamsters, one is forced to believe, of nothing at all. A tree is either a nuisance to these people, or a convenient post to which to tie their horses or to nail their scantlings. The owner does not yet realize the value of the trees, and is confident that a year or two of care will remedy the damage they suffer. But, in fact, the years following building operations and lawn making are years of low vitality for the neighboring trees, and they are in no condition to have their recuperative powers further taxed by avoidable bark wounds.

The remedy for this condition of affairs lies in a wider appreciation of the fact that serious esthetic, as well as financial losses can be avoided by consulting beforehand an expert in the care of trees, be he an arboriculturist, a consulting forester, or a landscape architect. If it pays to purchase the advice of an expert in heating or lighting before building a house — and if that is not done directly, it is done by the architect, unless he is an expert in those branches — it will certainly pay to consult some one, no matter what he may call himself, who has a really expert knowledge of trees. An error in handling trees is likely to be as difficult to remedy as an error in wiring a house, and may be quite irremediable.

Once the expert is found (often, unfortunately, not an easy thing to do) he will ask to see the architect's plans for the grading and drainage of the lot and for the location of buildings, walks, and drives. With these, and preferably in company with the architect and owner, he will visit the property. There he will examine the trees, noting their species and their physical and physiological condition. He will pay special attention to the soil, its surface covering, its texture, its condition of drainage. After this examination he will be able to forecast the effect the operations planned by the architect will have on the trees, and he will usually be able to suggest modifications in the plans in order to make them conform to the needs of the trees. If any of the trees have to be taken out he will mark those which are least valuable and least likely to survive under the new conditions. He will suggest the way in which the trunks of the trees are to be protected during building operations, and he will indicate the way in which limbs and roots must be removed, if that proves necessary. In addition, it need hardly be said, he will make very valuable suggestions as to the fertilizing, pruning, and spraying of the trees. The ideal way is of course to employ a landscape architect. He will not forget the needs of the trees while he is making the grounds convenient and beautiful.

If the building is to be done by day labor the owner should see to it that, before a team goes on the lot, the trunks and roots of the trees are protected by stakes or rough board guards. It must be made the duty of the foreman to see to it that none of his men, nor any of the other workmen or drivers who come to the place, in any way damage the trees. If the work is being done by contract, a brief provision should be included in the contract, specifying that the trees be protected and that no large limbs or roots be removed without the approval of the owner's expert adviser.

The myriads of woes of the street trees have long been the subject of lament by the friends of trees. That street trees in this country should at the same time be loved and praised so universally as they are, and so universally maltreated, is a subject of perennial astonishment. We plant a thousand trees and promptly murder nine hundred of them. The explanation possibly lies in our traditional idea, surviving from the period when we were subduing the forest primeval, that trees are a good bit like weeds, growing anywhere and standing any kind of treatment. It is an interesting sidelight on our municipal organizations that much of the damage to trees is inflicted by city employees. On one street the department of street trees will be setting young trees, while in the next street a gang of men may be chopping down fine trees which happen to be a few inches inside of a line laid down by an engineer who has never been in the neighborhood. The tree warden alone ought to be empowered to cut down trees, or even to remove large roots.

The subject of the protection and care of street trees has been treated so thoroughly by Dr. Fernow and Mr. Solotaroff, that nothing further need here be said about it.

This discussion of the right making and dressing and the prevention of wounds, however, does not exhaust what is to be said about avoiding the decay of trees. Sometimes the causes of decay lie deeper. Its presence may be due to soil exhaustion or to the fact that the tree is growing on a soil not naturally suited to it. Dr. Haven Metcalf, forest pathologist in the bureau of plant industry at Washington, speaking of all the diseases of woody plants, says: "The most widespread cause of disease of trees and shrubs is the attempt to grow them in a climate and situation for which the given species are not adapted." This, however, is a subject which is rather within the realms of horticulture and forestry than of tree repair. To foresters it is an immensely important matter. They find that on certain soils decay begins to attack the trees of a certain species at, say, fifty years, while on a more favorable soil the harvest can safely be deferred until the trees have stood seventy or eighty years. The obvious lesson to be drawn from this fact is that when trees are planted those kinds should be chosen which are known to do well on the given soil, and that the soil around the trees should be kept in good condition.

CHAPTER XIII

THE TRADE OF TREE REPAIR

THE trade of tree repair is as yet in its infancy. It is extremely important that its growth be strong and fairly rapid. The future welfare of the trees which are being planted by thousands in every town and city in the country depends upon the presence in those towns and cities of skilled tree workmen. As Prof. Sargent has said, "Time and labor are worse than wasted in planting unless the after care is intelligent, determined and ceaseless." The following brief comments on tree repair as a trade are offered not only in order to help, a little, men who are taking up the trade, but also with the idea of leading owners of trees to appreciate and use the services of such men.

The present condition of the trade is in many ways unsatisfactory, as was explained in the first chapter. The predominance in the work of a few large companies is attended by several undesirable features. The heavy expense of advertising, and of transporting and boarding the men, makes the work more expensive than it need be. It is not easy to have small jobs attended to promptly. The quality of the work inevitably suffers from the fact that the men who do it, for the most part, never see their work again. For the same reason, the work rarely receives the intelligent annual care which is so often essential to its permanent effectiveness. The men must do their work quickly and move to the next town. As a result the processes which require considerable time, such as the drying out of a moist cavity, are pushed through faster than is well. The men are instructed and hired to do cavity work, and the other branches of tree repair, especially prevention, are often neglected.

It would be highly desirable if, instead of this system, there were in every town a man or a group of men, thoroughly skilled in the work, who could go from place to place each year and attend to all of the tree work, and who could be called upon, in an emergency, by the most modest home owner. Such a workman would either himself be familiar with pruning and spraying, or would ally himself with such men. A man who is really skilful in repairing, pruning, and spraying trees ought to find work in plenty, the whole year round, for himself and one or two helpers, in any large town in the country.

The first thing a man is up against, naturally, is learning the trade. As with many other trades, there is no regular way to learn to repair trees. A few months with a good gang will give a man a fair start, but it is essential that this practical experience be supplemented by the study of the many books and government reports bearing on pruning, plant diseases, and noxious insects. Going into the woods and chopping rotten trees to pieces is an excellent laboratory training in connection with this reading. A man who develops a "tree sense" rapidly, masters the tricks of the cambium, and is endowed with a moderate amount of native gumption, will get hold of the work in short order.

When a man has learned the trade and is ready to set up for himself, there are several ways in which he can get into connection with the work. The old rule that every satisfied client brings another, holds in this as in every other trade and profession. If there is a professional landscape architect in the arboricultural workman's home town, he will be very glad to know of some one to whom to direct his clients. Landscape architects of other cities may also be interested. A card sent around to the owners of suburban estates, to the superintendents of cemeteries, and to improvement societies, will start connections which will quickly lead up to a large clientele.

Every effort should be made to secure regular clients who wish their trees inspected and given such care as they require every year. That procedure is much the most satisfactory, both to the client and to the workman, and is infinitely better for the trees.

The successful prosecution of a trade like this is largely dependent upon the promptness, accuracy, and definiteness of the business methods employed. If a number of different kinds of work are carried on at the same time, as pruning and cavity work, the expense of each should be determined and indicated separately in the bill. Materials must be separated from labor, and skilled labor from unskilled. When large cavities are filled it is highly desirable that the expense of each be determined. This can be done by keeping a time-card for each cavity, recording thereon the time which each man spends on it, and the amount which is used of each kind of material. These last details are not, of course, for the client, but they are extremely valuable to the workman, because they help him to estimate the cost of future jobs of a similar character. A reputation for accuracy in estimates is a valuable asset to a man in any business.

A few words to the owner of trees about the trade of tree repair may not come amiss. Of all the foolish things said about trees, the following is one of the most foolish and most common: " Well, I really have neglected my trees, but this

Ash tree with large cavity correctly treated with zinc

summer I am going to have the tree surgeons here, and then I won't have to worry about them any more." Trees are living things and they cannot be starved and wounded for years with the expectation that, with a wave of his fairy wand, the tree doctor will be able to restore them to strength and beauty. Trees are mostly tough and long-enduring, even under artificial conditions, but they cannot absolutely shift for themselves. The owner of a number of fine trees ought, if only as insurance, to have them inspected every year. One year not a tree in the grove will need to have any work done upon it; the next, a few hours spent in bolting up a limb over-strained in an ice-storm may save a beautiful tree from irreparable damage. An expert will detect signs of soil depletion or of the presence of insects which completely escape the eye of a layman.

Granted that this is the logical way to care for trees, how is the program to be carried out? The vital difficulty lies, of course, in finding men to do the work. The demand for men will be met, however, when it becomes intelligent and widespread. Owners should realize that it is to their own advantage to develop local arboricultural workmen, just as it is an advantage and economy to have plumbers and steam-fitters within a reasonable distance.

By this I do not mean that inferior work should be accepted from local men. There is no necessity for that. If owners learn to know good work, and set a high standard, they will receive good service. In case of doubt about a man, have the nearest landscape architect or professional arboriculturist examine him and his work.

Finally, a word to landscape architects. Your advice is worth nothing to your client unless it can be carried out at a reasonable expense. It is to your interest, as it is to your client's, to be able to refer him to a skilful and reliable man, competent to carry out the measures you recommend for the care of his trees. You ought to use every effort to get into touch with such men, and to help them when you find good ones. Give them freely of your special knowledge. Try to develop a corps of arboricultural and horticultural workmen upon whom you can depend as implicitly as the members of your sister profession, architecture, depend upon their carpenters and masons.

CHAPTER XIV

NOTES ON THE VARIOUS SPECIES

IN the preceding chapters trees have mainly been considered in general, the different species having been rarely mentioned. The various kinds of trees, however, are subject to different diseases and to different kinds of injury. These special needs demand special treatments. The present chapter consists of an alphabetical list of the commonest trees, with notes on the special characteristics, important in tree repair, which distinguish each kind. These notes are intended simply to indicate additions to or exceptions from the general rules previously laid down, and are in no sense complete guides to the treatment of the varieties concerned. If in a few cases these limits seem to have been exceeded, it is because the temptation was great to make this chapter a catch-all for facts and opinions which did not seem to fit in anywhere else.

APPLE

The name of the enemies of the apple is legion. Half-a-dozen fungi are common destroyers of its heartwood, the omnipresent white heart rot being foremost among them. The honey mushroom often infests the roots of the tree. Several bark rots and cankers are ever ready to complete the destruction of a weakened patch of the bark. Its insect enemies are no less numerous. Round- and flat-headed borers attack its heartwood and sapwood. Bark beetles girdle and kill the trees.

The apple is one of the commonest and one of the most difficult subjects to come under the care of the tree repairer. There are several reasons for that fact. In the first place, the apple is naturally very subject to the attacks of fungi and borers, as has been shown by the above enumeration of a few of its principal enemies. And it seems as if man had made every effort to help the fungi get at the apple's heartwood. When the young tree is planted too large a number of branches are permitted to grow out from the trunk, and they are altogether too close together. When the tree reaches maturity each of these limbs has become long and rambling, with a shock of branches and twigs at its end. To the lowest tier of these limbs one of two things usually happens. The limb may be killed by bark canker or blight, or by being overshaded as the trees in the orchard grow together. In the course of time the owner removes the dead limb. Its butt is often so closely squeezed in between other limbs that he rarely makes a close cut, even if he knows that he ought to, and a stump or snag remains as an open gateway for the fungi. If the lower limbs do not die they are frequently torn out by wind- or ice-storms, assisted by the natural leverage of the long horizontal limbs. The trunks and limbs, also, of these old, woody, slow-growing trees, push out calluses very slowly, and on them even small wounds are dangerous. Still further, these are the very trees which are most subject to injury, standing as they do near drives or barns or in the orchard, where wagons and tools run against them, and horses lunch on their juicy bark.

All of these influences, taken together, explain the gaping cavities which are seen at every hand in an old, neglected apple orchard.

Almost equally numerous are the considerations which make us wish to preserve the old trees. They are highly picturesque, and they give to the new house which happens to be built among them an immediate atmosphere of homeliness. They make excellent shade trees, and are very beautiful in bloom. Their fruit is often fair in quality and quantity, and there is a perennial hope in the human breast that both will next year be greater. Finally, the apple tree is one of the best loved of trees, and the associations which gather around a veteran Baldwin or Rambo may far outweigh other considerations which make the tree valuable.

Naturally, then, more apple trees have received repair work and cavity treatment than any other kind of tree. It is the purpose of the present paragraphs to enquire into the value of fillings in apple trees, and to try to formulate rules which may govern their use, and also to point out the special preventive measures which ought to be used in the prevention of cavities in apple trees, and the measures other than filling which are applicable.

In the first place we must distinguish the three reasons which exist for filling holes in apple trees. First, the trees may be filled simply for esthetic effect, decay being considered unpleasant by most people, on account of the popular association of decay, even in trees and buildings, with human death and disease, unless the decay is accompanied by an extraordinary degree of picturesqueness. Secondly, the trees may be filled to preserve them as ornaments to the home grounds or on account of their sentimental value. Thirdly, they may be filled to preserve them for their economic value as fruit producers.

Of fillings inspired by the first purpose it need only be said, what may seem superfluous, that, in case the entire elimination and prevention of decay and the restoration of the tree are decided to be impossible, and the holes are yet filled, simply for the sake of appearances, many of those precautions and measures which are indispensable to an ideal operation need not be taken. The processes to be omitted and the short-cuts which can be used will suggest themselves to one who understands the principles upon which the work of filling is based.

When the second purpose dominates we may presume that the factor of expense is practically negligible. It is safest, however, for the workman to warn the owner, before he begins, of the probable expensiveness and doubtful value of the work, if the decay is so advanced as to make success problematical. Then let him go ahead and do the very best job that skill and good materials will turn out. And he must not fail to see to it that the repair work is supplemented and given the best chance of being successful by careful pruning, spraying, and such soil treatment as may be necessary.

With the consideration of the value of cavity work in apple trees whose sole value is economic, we come to a very different subject. Here the factors are more tangible. Costs must be figured carefully in relation to returns. Expenditures must be fairly sure to accomplish the purpose for which they are made.

After considerable experience and observation, and after many interviews with men who have studied the matter carefully, the writer has become strongly of the opinion that fillings of even moderate size cannot be put into old apple trees at an economic profit. This conclusion is based on the following reasons.

1. Filling has no effect on fruit bearing. Those measures which do affect bearing should be tried, and their success should be assured before the trees are filled.

2. The value of old apple trees is at best very slight. They have often exhausted their soil, which can with difficulty be restored to good heart. Their tops contain but little healthy bearing wood. They are often infested with scale and fungous diseases.

3. The fillings are by no means certain to accomplish their purpose of stopping the course of decay. The reason for this lies in the ease with which insects and decays attack the apple tree, and especially the susceptibility of apple bark to decay. There is also the difficulty of completely eradicating the decay, if it has worked up into the limbs. The heavy strain put upon the filling by the leverage and swaying of the limbs, and the slowness with which old trees build calluses, also conspire to make peculiarly difficult the filling of old apple trees.

This matter of the restoration of old orchards to profitable bearing is now very much talked about. The impression seems to prevail that no tree is so bare-limbed and decayed but that it can be restored to bushy, fruitful vigor. It may be true that there is hardly a tree which cannot be improved by pruning and fertilizing, but the pomologists of the Ohio Experiment Station, who have studied this matter carefully, assert that rejuvenation cannot be a commercial success when practised upon trees more than thiιty or forty years old, upon trees in an advanced condition of debility and decay, or upon trees with long, bare limbs and high, thin tops. It costs more to bring such trees back into bearing (if it can be done at all) than it does to plant young trees and cultivate them until they become profitable.

If an attempt is made to restore vigor to apple trees which contain large cavities, the success of the restorative measures should be assured, as has been said, before the filling is done. In most cases the open system of wound treatment, involving cleaning, draining, and dressing, but not filling, is preferable to filling.

It may be well to append here a sketch program for restoration work upon old apple trees, even though this one may not be much unlike programs which have been suggested in other connections. The first three processes should be carried out immediately.

1. Attend to the soil, giving it such cultivation, fertilization, drainage, or mulching, as it may require.

2. Spray at such seasons and with such materials as may be indicated by the fungi and insects attacking the tree.

3. Prune. Normally a severe heading-back will be beneficial, but the operation must be modified to fit the case in hand.

4. Brace weak limbs.

5. Treat wounds.

6. Fill cavities.

BEECH

The beech is subject to the attacks of many fungi. It is one of the favorite hosts of the white heart rot, the worst enemy of deciduous trees. "Wherever any considerable amount of beech timber is found," say von Schrenk and Spaulding, "white heart rot is prevalent. In some sections as many as ninety to ninety-five per cent. of the beech trees of merchantable size have been found affected with this disease."

The beech tree is rather tenacious of life, however, and the decay may fill its trunk for several decades before the tree succumbs.

No special directions are necessary for handling the excavation. The bark around the edges of the cut is a little more liable to dry out than in the case of some trees, and care must be taken to keep it shellacked or waxed.

A mature beech grows so very slowly that the production of callus is often quite negligible. I have seen cuts in positions normally favorable to callus growth where a callus of barely a quarter of an inch had developed in four or five years. In such old trees the filling should be put in with the idea that it must be effective without the help of a callus-covering over its edges.

The beech is extremely touchy as to soil changes, and especially to an increase or diminution of the water supply. In case a serious change of that nature takes place the top of the tree is likely to die back. Remedial measures should at once be applied to the soil, and the affected branches or portion of the stem should be removed promptly, or they may form gateways for the entrance of decay into the surviving parts of the tree. The cuts thus made should be dressed with the greatest care.

Some types of beech are much easier to work in and prune than others. There is a pronounced type in which the limbs leave the trunk at a sharp upward angle, forming many bad crotches. Such trees seem more subject to decay than the normal type, in which the limbs leave the trunk at right angles. The upright limbs persist, when they die, much longer than do the horizontal limbs, thus giving fungi a better opportunity to gain entrance to the trunk.

The beech does not react well to the severe pruning system of rejuvenation, unless the remaining framework is well clothed with twigs.

BIRCH

One of the problems in connection with work in the white-barked birches (as well as other genera which have white or light bark) is the avoidance, in so far as is possible, of disfiguring applications, such as tar and asphalt. On such trees white-lead paint of the right color should be used, if the tree is conspicuously placed.

Arboriculturists are frequently asked what can be done about the ugly black scars which result from peeling off rings of the white outer bark. There is no cure for such a wound. An application of varnish immediately after the infliction of the injury might prevent to some degree the cracking of the exposed inner bark. The black band can of course always be painted white, which is advisable, especially when the tree, though within view, is sufficiently far away to prevent the patching from being too conspicuous.

CATALPA

The globular catalpa, *Catalpa Bungei,* which is so much in vogue just now, often breaks to pieces in summer storms after it has attained fair size. It is certain to lose large limbs by the time it attains a spread of twelve or fourteen feet. Preferably, it should be pruned annually and restrained from getting so large. Broken tops can often be propped up to last out the season. No effort should usually be made to remedy the trouble permanently. Cut off all the split limbs and prune the others back severely. In a few years the top will regain size and symmetry.

CHERRY

The black-knot which infests cherry trees and other stone fruits so widely can be cured only by complete excision or by the removal of the limb on which it occurs. The parts removed must be burned. It has not yet been found possible to kill the causal fungus by means of any kind of application.

In making incisions in the cherry difficulty sometimes arises from the fact that the bark rolls back from the cut edge, detaching itself from the wood and drying out. The same phenomenon accompanies frost cracks and greatly increases their seriousness in the cherry. The explanation of course is that the outer bark of the tree is under tension, and when the opportunity occurs for it to contract it does so and tears the soft inner cortex from the wood. A few nails half an inch or so from the edge of the bark, not driven in too far, will prevent it from rolling back. In other cases shallow cuts through the tough outer bark, parallel to the main incision, may accommodate the strain, though at a loss to the beauty of the trunk. This characteristic of the tree should be remembered when slits are being cut in a trunk which is supposed to be bark-bound.

CHESTNUT

Sufficient has already been said about the chestnut bark disease, and about the foolhardiness of doing much repair work on trees within the infested or the danger zones.

Even outside of that region (if any part of the continent can really be considered outside of the danger zone) it is not a tree which should frequently receive expensive fillings. The chestnut responds well to the pruning-back process, and hollow old trunks can be made to support luxuriant, even though not very lofty, tops. In the main, such old trunks cannot be helped by any kind of repair work, especially if they are infested by the red powdery heart rot, *Polyporous sulphureus*. Thousands of dollars have been spent in trying to excavate and restore veteran trees affected by this decay, but, in the writer's judgment, with not one chance in a hundred that the work will prove effective. It seems to him far preferable to shorten in the limbs of the tree so as to take some of the strain off the trunk. If any work is done upon the hollow trunk it should be limited to such measures as will prevent the access of insects to the interior. If a tree repair man advises filling a tree infested with this decay, the owner should require a survey to be made of the trunk, and a vertical section should be drawn, showing how much of the trunk is invaded. A prediction should be made, also, of the nature of the incision which will be required to remove the decay from the trunk, and from the roots as well, if it has worked down to the base of the tree. During the progress of excavation the owner should see to it that the tree man has been honest in his survey and thorough in his excavation.

Healthy trees should be carefully protected from fungi, which usually gain entrance through dead limbs and wounds in the upper part of the trunk. It is essential that sickly limbs be promptly removed and that wounds be effectively dressed.

ELM

The elm is subject to the usual quota of diseases. One wood rot which the writer has found rather common in northern Ohio he has not identified as any of the named fungi described by von Schrenk and other writers on the diseases of trees.

The wood most recently invaded can with difficulty be distinguished from the healthy wood, save that it is a trifle " short " and a bit browner. Wood longer affected becomes soft, moist, and sour-smelling. The center of the trunk, if the decay has progressed so far, is hollow, with webby masses of powdered rotten wood clinging to the walls of the cavity and heaped at the bottom. It is an extremely unsatisfactory decay to excavate on account of the difficulty of determining where it leaves off. A compound microscope would probably be the only sure arbiter. Bad cases of this decay are better left alone.

No special notes are necessary upon the treatment of cavities in elms, except to call attention to the moistness of the wood and the great desirability of permitting cavities to dry out thoroughly before dressing and filling them. When possible it is very advantageous to permit the cavity to stand a month or two with only a preliminary dressing of some non-filling antiseptic solution such as sulphate of copper or corrosive sublimate. If at the end of that time the wood is dry, the heavier dressings can be applied and the filling put in.

The elm is more frequently affected than any other tree by the " slime-flux " which has already been described, along with such preventive measures as are known.

The elm, as is a matter of common observation, frequently requires bracing, a result of the manner in which the limbs leave the trunk, or, rather, in which the trunk breaks into limbs. Bolts should of course be used in bracing the spreading limbs of the elm, and never bands or chains.

HEMLOCK

The hemlock does not often come under the care of the tree repairer, although the arboriculturists of the large public parks may occasionally have to prescribe for its treatment. It is subject to a red heart rot (among others) which may be excised if it has not progressed too far. A careful survey should precede the attempt. Most fungi probably gain extrance to the trunk through dead branches, which should be removed if of any considerable size, even though such pruning may lessen the picturesqueness of the tree.

HICKORY

Besides an average liability to the general run of tree difficulties, the hickory is more than normally subject to becoming bark-bound, on account of the extreme toughness of its outer bark, which in pioneer days was used to make barrels and to roof log cabins. Vertical slits through the outer layers of the cortex are the remedy.

HORSECHESTNUT

Being a planted tree, there is no reason why the horsechestnut need often be diseased. It is occasionally subject to frost crack, which is of course not preventable. The bad crotches which so often result in cracks and broken branches can be prevented by proper pruning while the tree is young. It should never be allowed to bifurcate into parallel main trunks, a tendency to which it is rather subject.

LINDEN

The linden is preyed upon by many rot fungi, which gain entrance through the many wounds and cracks to which the weakness of the wood predisposes the tree. Frequently the decay destroys the wood in the vicinity of the wound through which it gained entrance, and the top of the tree is then broken off, leaving a stump perhaps fifteen or twenty feet high. Such stumps usually send out adventitious shoots, and develop new tops. The trunk of such a second-growth top is of course invariably decayed, and it is a question whether it is ever worth while trying to remedy the difficulty. The new limbs should be thinned out so that they will not squeeze each other, and they should be cut back occasionally if they get so long as to overstrain the security of their anchor-age to the trunk. The linden sends out adventitious shoots freely, especially if limbs are removed in winter or very early spring. No old wreck which is still alive should be abandoned until the severe pruning method of rejuvenation has been tried.

Though the wood of the linden is rather fragile, the bark is tough, and limbs which are bent and fractured by storms, and yet not quite separated from the tree, may continue to grow. As a result of this fact, all sorts of queer and erratic formations are constantly being observed in an old linden grove. Many of these spell puzzling cases for the pruner and repairer. The latter must often depend on a free use of tar, for to clean and mend every crack and hole in a large tree would frequently entail almost endless labor. In no case should these minor cavities be merely filled with little dabs of concrete-mortar, as is so often done by enterprising amateurs. In working on the linden the best must often be made of a bad job, frequent reliance being placed upon the tree's capacity for replacing limbs which are so badly broken and twisted that they have to be removed bodily.

Nevertheless, unnecessary wounds should be avoided by carefully bracing valuable trees. In deciding where braces are needed, the weakness of the wood should be kept constantly in mind.

BLACK LOCUST

The great fact about the locust, from our standpoint, is its susceptibility to the attacks of the locust borer. As a result its chances of long life are so small that expensive work upon it is not often justified. There is a yellow heart rot which gains entrance to the wood through the burrows of the borers.

MAPLE

The maple, being one of the commonest and one of the best-loved shade trees, of course comes frequently under the gouge, so to speak, of the tree repairer. In the main they involve nothing more than straightforward work. The red maple, as has been said, is subject to frost cracks. The silver maple has an inveterate tendency to form bad crotches, which must be fought in small trees by careful training, and its effects must be negatived as far as is possible in old trees by bracing. The red maple (and perhaps equally the silver) often shows long shallow wounds in the upper limbs, the result of the tearing out of minor branches. The open treatment is usually the best way to handle these wounds, though good jobs of tinning can often be done upon them. The red and silver maples are good subjects for severe pruning, sending out adventitious shoots very well. The sugar maple does so less readily.

OAK

The oak is so typical a tree that almost all of the general rules apply perfectly to it. The wood decays slowly and it is possible to make complete and satisfactory excavations in a larger proportion of cases in working on the oak than on almost any other tree. The tree is also generally worth the cost of the work, on account of its longevity and its power of resisting storms and of accommodating itself to changing conditions. When old it forms calluses slowly and wounds must be kept well covered. The apparent soundness of the surface of an exposed area of wood may mask a considerable thickness of decay just below it.

Though the common supposition that oak limbs are exceptionally strong is well-founded, in some cases extra caution must be employed in climbing oak trees. The long limbs of open-land red oaks are sometimes so infested with boring insects and fungous decays, that they snap off without the slightest warning, though apparently quite large and strong enough to bear a considerable weight.

SYCAMORE

Sycamores are very frequently quite hollow. As the tree bears pruning well, it is always wise to consider the possibility of severe pruning as an auxiliary to other restorative measures. The hollow trunks can usually be more effectively handled according to the open system than by filling.

TULIP

The wood of the tulip tree is not strong, and through the frequent wounds resulting from this fact, decay fungi enter rather easily. Consequently the tulip frequently requires bracing as well as cavity work. Sometimes the heavy horizontal limbs on open-ground trees fairly break from their own weight. I have seen such limbs with dead patches on their upper surfaces a few feet from the trunk. The wood of the upper part of the limb had actually been fractured crosswise, the sap flowing solely through the sapwood and bark on the under side of the limb. Stiff bracing and thorough applications of antiseptic dressings are indicated for this condition of affairs, unless it is possible to remove the affected limb.

WALNUT

The wood of the black walnut, exceptionally resistant to decay when seasoned, is not frequently attacked when in the tree, although sometimes infested by the red and the white heart rots. An interesting characteristic of the tree is the way in which the base may be open and quite eaten out, while the upper parts of the trunk are quite sound.

WILLOW

The soft wood of the willow (and not less of its relatives, the poplars and cottonwoods) is quickly decayed when once exposed to the elements. Very old willows are rarely sound if they have been seriously wounded, as they usually are, sooner or later, by the tearing away of one of their large branches. Cavity work is rarely worth while on old and contorted willow trunks, though it may be quite valuable in the case of younger trees. Willows grow so fast that wounds are healed with astonishing rapidity, if the tree is given half a chance. There is plenty of opportunity for preventive work on willows, not letting the limbs crowd each other or form dangerous crotches, and bracing promptly limbs which promise to grow beyond the limit of their own strength. Willows often send out roots from the side of a wound in the bark. These roots either work down to the ground or else, if the trunk is far decayed, spread out in the rotten wood of the tree's own trunk, thus making the best of a bad business.

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